Three essays on capital structure and structured finance

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Gabriel H. Neukomm
from Zollikon und Hallau, Switzerland

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Prof. Alexander F. Wagner, PhD
Prof. Dr. Michel A. Habib

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Contents

List of Figures

List of Tables

Part I

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Part II

Research Papers

Chapter 1

Structured finance, acquisitions and debt agency

Gabriel H. Neukomm[1]

Abstract

Modern corporations use complex debt instruments and pursue acquisitions. In order to analyze the properties of some of these contracts in the event of an acquisition, this paper considers a company that has an incumbent capital structure, comprising one of five practically important structured debt contracts. An opportunity for an acquisition comes along that was not ex-ante contractible. The equityholder decides on the financing of this expansion by trading off tax advantages of debt against costs of bankruptcy. The model yields a number of insights for structured debt and acquisitions, four of which are as follows: First, a seniority clause offers the bondholder protection from agency, but it also decreases the equityholder's incentives to finance the acquisition. Second, embedded call options are valuable even if interest rates are constant, because they allow the equityholder to issue a new bond at fair value. Third, bankruptcy remoteness is valuable, if assets are very risky. Fourth, convertible bonds are vulnerable to agency and the conversion option bears the same incentive problem as a seniority clause. These properties explains, for example, the otherwise puzzling practice of companies buying out convertible bond holders prior to an acquisition.

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1.1 Introduction

Earlier literature about capital structure and investments, Modigliani and Miller (1958) for the financing side or McDonald and Siegel (1986) for the investment side, suggested that the investment decision may be disconnected from the financing decision as the Fisher Separation Theorem suggests. However, a number of papers like Gomes and Schmid (2010) have pointed out that in the presence of frictions, the investment decision and the financing decision of an individual firm, have to be evaluated jointly. It is already mentioned in the original Modigliani and Miller (1958) paper that: *These [...] drastic simplifications have been necessary in order to come to grips with the problem. Having served their purpose they can now be relaxed in the direction of greater realism and relevance, a take which we hope others interested in this area will wish to share.*

In an insightful paper Leland (1998) laid the foundations for what is since known, as the *structural model for capital structure.* He analyzed the agency conflict between bondholders and equityholder over the operational as well as over the financial risk policy of a corporation. An interesting stream of literature on debt agency has evolved over time, analyzing financing and investment decisions jointly, usually under a capital structure that contains straight debt and equity. Mauer and Sarkar (2005) extended the theory toward financing real options and elaborated on the conflict of interests between the same pair of agents. Sundaresan and Wang (2008) on a theoretical level and Hennessy and Whited (2005) on an empirical level, added some insights about leverage ratios, implying lower leverage ratios for non-mature companies.

Most of the literature on financing real options address the question of the optimal capital structure and the value added or lost due to an acquisition only for the most basic form of debt - a straight bond. This stands in conflict with the large industry and volume of *structured debt contracts.* This market experienced a set back due to the late 2000s financial crisis. But in Q2 2010 emission volumes of structured debt contracts are - a least according to press reports - recovering.[2] A small number of papers have analyzed different forms of debt contracts, but mostly with respect to other issues than acquisitions and debt agency. Childs et al. (2005) showed that financial flexibility achieved by shorter debt maturity has an overwhelmingly positive effect on the agency conflict between the equityholder and the bondholder. In Leland (1998), the same thing was found to be inefficient. Hackbarth et al. (2008) analyze the consequences of using bank debt as opposed to public debt on leverage ratios and the choice of seniority. Martellini

[2]See e.g. "Bank of America Said to Market 300 Million CLO for Tetragon", by Pierre Paulden, Bloomberg, Jul 19, 2010 or in general on the subject "Bringing back CLOs", by Vipal Monga, The Deal Magazine, November 27, 2009.

and Milhau (2009) look at the choice of fixed vs. floating rate debt, but within an asset and liability management perspective. Hennessy and Tserlukevich (2008) consider convertible and callable bonds within a Leland (1998)-model. This is however a model of risk switching instead of investmenting and there are no unexpected actions.

In a second insightful paper, Leland (2007) analyzes the financial synergies that asset securitization may provide. He starts with the observation, that issuer of asset backed securities use rather abstract terms when explaining the value added of securitization, such as the claim that it *unlocks hidden asset value.* The paper analyzes how financial benefits of a merger depend upon asset volatility as well as on the correlation between incumbent assets and new assets. In that paper however, there are no diverging interests between the bondholders and the equityholder and thus no room for agency conflicts.

In the present paper, I analyze the value added, potential agency gains/losses and potential welfare loss associated with five distinct structured debt contracts in the event of an unexpected corporate acquisition. In a two-period trade off model of capital structure, this paper sets to answer the following questions:

1. How do bondholders and equityholders gain or lose on grounds of an unexpected acquisition given an incumbent structured debt contract? Who is it that incurs losses or realizes gains?

2. How is the direction as well as the order of magnitude of these value shift influenced by risk, bankruptcy costs and taxes?

3. What part of these gains or losses are associated to agency?

4. How relevant is the welfare loss associated with agency?

5. What forms of structured debt contracts observed in practice shield against agency costs? What forms favor agency costs?

6. What is a good debt contract if unexpected acquisitions are potentially an issue.

The setup in this paper in some sense includes an incomplete contract on restructuring, since it is assumed that further capital structure adjustments are not contractible ex ante. Any kind of gains/losses associated with agency in this paper are the result of limited contractibility. The two period model I consider, is an extension of the model in Leland (2007). There exists one company that has an incumbent capital structure and incumbent assets. These assets are normally distributed. A merger or an acquisition becomes available to the company, that requires fresh capital if it is pursued. This comes as a surprise for all stakeholders, which is different to sequential financing, where the future investment needs are known ex ante. So it is a situation of imperfect rather than asymmetric information, what makes the situation a problem of incomplete contracting. All the bargaining power in this paper is assumed to be in the hands of the equityholders.

The incumbent capital structure in the setup in this paper contains equity and a debt contract, which can be

- I) an unsecured straight bond without priority (this is the benchmark)
- II) a senior secured straight bond
- III) a callable bond
- IV) a single asset and single tranche collateralized loan obligation (CLO)
- V) a convertible bond

A word on the meaning of the term *structured finance* at this point: There are commonly two meanings associated with this term. First, structured finance in a narrow sense means the kind of contracts that boomed prior to the late 2000s financial crisis, which were termed collateralized loan obligation (CLO). One of the main feature of that kind of debt contract is that it is secured with specific asset(s) which are transferred to a bankruptcy remote special purpose entity. So in its narrow meaning, structured finance is equivalent to asset securitization or project financing. In the narrow sense of the word only contract (IV) - which is a single asset and single tranche CLO - is a structured debt contract. This is the way the term is used in Leland (2007). Second, in a broader sense the term structured finance means all kind of debt contracts that have more complex contractual clauses than a simple straight bond. This is how the word is used in Vanden (2009) or in Jobst (2007). That is also the way the term *structured* is used in connection with structured products that are sold to investors in wealth management. Therefore in its broad meaning contracts (II) - (V) are structured debt contracts. I will use the term in its broad meaning and consider its narrow meaning as a specific form of structured finance, namely asset securitization.

The capital for the acquisition is raised by an optimal package of equity and straight debt only. This has two reasons: First, the conflict of interests arises between the incumbent bondholder and the equityholder, so the incumbent debt contract is the object of interest not the new debt contract. The new bondholders receive a fairly priced bond independent of what kind of debt contract they buy, anything else would be arbitrage. Second, it limits the number of situations considerably. The decision of the capital structure is taken either to maximize the company's total value or to maximize the value of the company's equity stake. The objective function is a trade off, optimizing between the tax advantage of debt and the costs of bankruptcy, as first formalized by Kraus and Litzenberger (1973).

An acquisition may lead to *value added* which is the value added or lost that the incumbent bondholders and the equityholder realize. Similar to Leland (2007), it is assumed that assets are additive i.e. that there are no operational synergies associated with acquisitions. A value increase/loss of one stakeholder is therefore either an overall value added provided by the acquisition or a transfer of value from one stakeholder to the other. There are five sources that drive value added: the volatility of the acquired assets, the tax shield, the bankruptcy costs, agency costs and limited liability. An acquisition may increase or decrease the former four, depending on the specifics of the incumbent debt contract, the incumbent assets, the new debt contract and the new assets. The effect of limited liability is always value decreasing as it has been noted by Sarig (1985) and others.

Agency costs/gains are a subset of value added, that is realized as a direct consequence of implementing an equity maximizing rather than a value maximizing capital structure i.e. agency costs are a transfer in value from the bondholder to the equityholder. There may also be a welfare loss or deadweight loss, which is the loss in overall value on implementing an equity maximizing capital structure rather than a value maximizing capital structure.

There are two distinct forms of agency occurring in this model: Through controlling the acquisition the equityholder may influence the overall volatility of the company's assets. From the bondholders perspective the equityholder may engage in what was termed *asset substitution* in Jensen and Meckling (1976). This term means a transfer of value from the incumbent bondholder's claim to the equityholder's claim through a worsening of the quality of the company's assets. This also works indirectly: The equityholder may take on excess leverage that is pari passu to the incumbent bond in order to dilute the incumbent claim. This is termed *debt dilution*.[3]

The second agency problem is an underinvestment problem of the equityholder. Originally, it was termed *debt overhang* by Myers (1977). It is the problem that some of the additional capital that the equityholder invests or more precisely some of the profits that this additional capital yields, is ex post claimed by the bondholders. The bondholder free rides on the equityholder's

[3] See e.g. Schwartz (1989).

additional capital outlay.

Question 2 at the beginning refers to three parameters of interest, risk, bankruptcy costs and the tax rate. I will offer on each of the three parameters a perspective to analyze the effects of an unexpected acquisition on the structured debt contracts. With the term *perspective* I refer to an appropriate two dimensional grid over which a mesh of e.g. added value for the equityholder is drawn. A perspective is therefore a three-dimensional representation of value added, agency costs, etc. This allows to see how the value of the contracts evolves over an extensive set of values for the key parameters risk, bankruptcy costs and the tax rate. Whenever possible, the numerical findings are affirmed with anecdotal evidence from the financial market.

By analyzing these three perspectives, it is shown that unsecured straight debt is vulnerable to agency - more precisely claim dilution - unless risk is low and the tax rate is high. In terms of bankruptcy costs, agency costs are the worst when bankruptcy costs are at an average level.

A seniority clause helps to protect the bondholder from this form of agency, but it gives raise to the other agency problem that is similar to debt overhang. As a consequence of the seniority clause, the bondholder profits form the equityholder's investment without contributing to it. The equityholder's value added from an acquisition is then reduced or even negative.

An embedded call option can help to overcome this latter agency problem, since it allows the equityholder to refinance an incumbent bond. The incumbent bond, whose value potentially increases after the acquisition, may then be replaced with one whose price is exactly at fair value after the acquisition.

Securitization offers another way to overcome the second agency problem but with a different tool, namely bankruptcy remoteness. The assets are kept separately from each other such that there is no issue with debt overhang. Moreover, bankruptcy remoteness can reduce financing costs if the acquisition is very risky, because if one asset is in distress it cannot infect the other. The equityholder can, similar to Leland (2007), further profit from additional limited liability that is provided by the additional entity.

A convertible bond - often praised as sweetened debt - is problematic: In Green (1984) it was argued that convertible bonds are a solution for asset substitution. However, similar as in Hennessy and Tserlukevich (2008), the agency problem that occurs and the equityholder's incentives depend on whether the bond part or the option part of the convertible bond dominates. When it is the bond part that dominates, the convertible bond is - similar to an unsecured bond - vulnerable to claim dilution. When it is the conversion option that dominates, the equityholder has a constant debt overhang problem, similar to a seniority clause. This is because the conversion option allows the bondholder to profit form the equityholder's additional capital outlay to finance the acquisition - without contributing to it. A conversion option potentially prevents asset substitution as proposed by Green (1984), but it exchanges it with a debt overhang problem. For that reason, a convertible bond ought to be issued callable and should be called prior to acquisitions. Vanden (2009) proposes an altered payoff structure for a convertible bond that adjusts itself to the value of the assets. However, that payoff structure bears large bankruptcy costs and it is at least questionable whether it would be qualified as debt for tax and bankruptcy purposes.

The conclusion is that - within the scope of this model - a callable bond with a seniority clause is the optimal choice for a company that potentially has to deal with unexpected acquisitions. It offers protection against both forms of agency and allows to redeem the bond when an acquisition is carried out. Securitization is the optimal choice if the risk of the acquisition is very high. Then bankruptcy remoteness becomes valuable.

The remainder of the paper is organized as follows. Section 1.2 introduces the model. Section 1.3 delivers the results and predictions of the model and relates it to anecdotal evidence. Section 1.4 offers recommendation for debt structuring. Section 1.5 concludes.

1.2 The model

The model I present in the paper to analyze debt structuring and acquisitions is a two period trade off model of capital structure. It is essentially an extension of the model in Leland (2007). What makes the model in this paper different from the model in Leland (2007) is that i) structured debt contracts are analyzed and ii) more than one debt contract may be on the company's books. Without the later one does not have an agency conflict, which is the case in Leland (2007) and which is what is intended by the respective paper, since the questions addressed in that paper are different form the questions addressed in the present paper. In this part, the model is introduced.

1.2.1 The basic model - A corporation with one asset and one straight bond on its books

1.2.1.1 Corporate tax law and corporation law

Two common characteristics of corporate tax law and corporation law are part of this model: i) A corporation's operational activities are subject to corporate taxation, the tax rate is denoted by τ, ii) interest payments on corporate debt are tax deductible and iii) a corporation enjoys limited liability.[4] A corporation in this model is therefore similar to the payoff of a call option written on the company's assets with strike price zero. As already mention in Leland (2007), there is a cross dependency here: The value of the debt influences the interest expenditures, the interest expenditures influence the value of the tax shield and the tax shield influences company's asset value. But the company's asset value in turn influences the value of the debt.

1.2.1.2 Assets and environment

The model is a two period model, so there are only two points in time relevant to the model, namely $t = 0$ and $t = T$, where T is some point in the future. An asset in this model is denoted by X_i^t, where i denotes the index and t the time. Assets are future cash flows generated at $t = T$ by some business activity. Assets are assumed to be normally distributed, with some mean $\mu_i \in (0, \infty)$ and some standard deviation $\sigma_i \in (0, \infty)$ i.e. an asset is fully defined by the pair (μ_i, σ_i).[5] If a company owns two assets, these two assets have some correlation $\rho_{i,j} \in [-1, 1]$. There are no operational synergies in this model i.e. payoffs are additive. There exists a risk free asset or a risk free interest rate r_f. Also, universal risk-neutrality is assumed. This immediately implies that at $t = 0$, asset i's value needs to be equal to

$$X_i^0 = \mathbb{E}\left[\frac{X_i^T}{\left(1 + r_f\right)^T}\right]$$

i.e. the discounted expected value.

1.2.1.3 A straight bond in this model

A straight bond in this model is a financial security, that promises to pay an amount or principal P at maturity. At $t = 0$ the corporation issues such a security at fair market value $D(P)$. The difference between P and $D(P)$ is the interest paid on this debt contract. Since interest payments are tax deductible, the company is - given it has a straight bond on its books - only subject to taxation if the company's earnings are higher than its interest expenses i.e. if

$$X_i^T > P - D(P) \equiv X_{ZT} \tag{1.1}$$

[4] Especially the second feature of corporation law is - according to Armour et al. (2009) - a fundamental principle of corporation law. As such it is found in next to every developed jurisdiction.

[5] *Financial* assets are commonly assumed to have a support greater than zero. However, real assets may have a value less then zero. One may think of an activity that causes huge claims for compensation for damage.

where X_{ZT} denotes the zero tax boundary.[6]

A company files for bankruptcy if the value of its assets at $t = T$ are below P. Since it is a two period model, a default leads to a liquidation in the spirit of Chapter 7[7] or Title 6 of the Swiss Bankruptcy Code[8]. Together with the deductibility of interest paid on the bond, this implies that in this model a company defaults if its after tax earnings are below the bond principal i.e. if

$$0 \geq X_i^T - \tau \max\Big(X_i^T - X_{ZT}, 0\Big) - P \tag{1.2}$$

The asset value that triggers default is the asset value that solves equation 1.2 and is denoted by X_d ($\equiv$ default boundary). One needs to have $X_d \geq X_{ZT}$, otherwise the interest payment would exceed the final fixed payment which is a contradiction.[9] A company therefore defaults in this model if

$$X_i^T < X_d \equiv P + \frac{\tau}{1-\tau} D(P) \tag{1.3}$$

where the right hand side is just the solution to equation 1.2.[10] Default is assumed to be costly, if a company defaults some fraction α of asset value is lost. Given corporate taxation and costly default, an optimal capital structure can be derived that is the solution to the trade off first formalized in Kraus and Litzenberger (1973), where the tax shield is traded off against bankruptcy costs.

The question arises, how interest payments have to be treated, when a company is in default. In Leland (2007) it is assumed that the company - and thus its bondholders - retain full interest deduction in default. Kim (1978) argues, based on a legal assessment, that creditors of a bankrupt corporation will most likely lose the tax shield. I will follow Kim (1978) and assume that bankrupt corporation lose their tax shield.[11]

[6] Equation 1.1 corresponds to equation 7 in Leland (2007).

[7] 11 United States Code (2010), Chapter 7.

[8] Bundesgesetzt über Schuldbetreibung- und Konkurs (SchKG), SR 281.1.

[9] This is shown in Leland (2007), page 771.

[10] Equations 1.2 and 1.3 correspond to equations 10 and 11 in Leland (2007).

[11] Under Swiss Law, namely under §149(4) of the Swiss Bankruptcy Code, post petition interest is not tax deductible. Under the United States Bankruptcy Code (11 United States Code (2010)) it is less clear: The wording of §502(b)(2) of the United States Bankruptcy Code implies the same regime as under Swiss law. The case law on this matter is opaque. As note in Potter (2002), there seems to be a conflict between state level courts and the Circuit Courts. In the case of *In re Continental Vending Mach. Corp.* (77-1 U.S.T.C., 9121 (E.D.N.Y. 1976)) as well as in *Kellogg v. United States (In re West Texas Marketing Corp.*, 54 F.3d 1194.) the second and the fifth circuit court have denied deduction of post petition interest to bankrupt corporations. In the case *In re Dow Corning Corp.* (270 B.R. 393.) the Eastern District of Michigan Bankruptcy Court has granted deduction of post petition interest.

Given the real and legal environment in this model, the fair market value $D(P)$ of a straight bond with principal P on the books of company with one asset is

$$D(P) = \frac{1}{(1+r_f)^T}\left(\int_{X_d}^{\infty} P dF_{X_i} + (1-\alpha-\tau)\int_0^{X_d} X_i dF_{X_i}\right) \tag{1.4}$$

where first term in equation 1.4 represents the repayment if the company is solvent while the second term represents the liquidation proceeds if the company is in default. The market value of the equity $E(P)$ is

$$E(P) = \frac{1}{(1+r_f)^T}\left(\int_{X_d}^{\infty} (X_i - P)\, dF_{X_i} - \tau \int_{X_d}^{\infty} (X_i - X_{ZT})\, dF_{X_i}\right) \tag{1.5}$$

where the first term in equation 1.5 represents the equity holder's residual equity claim while the second term represents the tax shield. Using the fact that the asset X_i is assumed to be normally distributed, $D(P)$ and $E(P)$ can be expressed as

$$D(P) = \frac{1}{(1+r_f)^T}\left(P\left(1-\Phi\left(\frac{X_d-\mu_i}{\sigma_i}\right)\right) + (1-\alpha-\tau)G(0, X_d, \mu_i, \sigma_i)\right) \tag{1.6}$$

and

$$E(P) = \frac{1}{(1+r_f)^T}\left((1-\tau)G(X_d, \infty, \mu_i, \sigma_i) - (P - \tau X_{ZT})\left(1-\Phi\left(\frac{X_d-\mu_i}{\sigma_i}\right)\right)\right) \tag{1.7}$$

where

$$\phi(x) = \frac{1}{\sqrt{2\pi}}\exp\left(-\frac{1}{2}x^2\right);\ \Phi(x) = \frac{1}{\sqrt{2\pi}}\int_{-\infty}^{x}\exp\left(-\frac{1}{2}y^2\right)dy = \frac{1}{2}\left(1 + erf\left(\frac{x}{\sqrt{2}}\right)\right)$$

$$G(x_d, x_u, \mu, \sigma) = \int_{x_d}^{x_u}\frac{X}{\sigma}\phi\left(\frac{X-\mu}{\sigma}\right)dF_X = \mu\left(\Phi\left(\frac{x_u-\mu}{\sigma}\right) - \Phi\left(\frac{x_d-\mu}{\sigma}\right)\right) + \sigma\left(\phi\left(\frac{x_d-\mu}{\sigma}\right) - \phi\left(\frac{x_u-\mu}{\sigma}\right)\right)$$

$\phi(x)$ is the probability density function of the standard normal distribution, $\Phi(x)$ is the cumulative distribution function of the standard normal distribution, $erf(x)$ is the error function while the function $G(x_d, x_u, \mu, \sigma)$ is the expected value of a normally distributed random variable of the form $\mathbb{E}\left[X\mathbf{1}_{\{x_d \le X\}}\mathbf{1}_{\{X \le x_u\}}\right]$ where $\mathbf{1}_{\{\,.\,\}}$ denotes the indicator function. Form here on forward all remaining expressions for the fair market value of corporate claims are expressed using the fact that assets are normally distributed. The above equations 1.4 - 1.7 correspond to equations 12, 14, $A4$ and $A5$ in Leland (2007).

1.2.1.4 Optimal capital structure

The optimal capital structure is determined by selecting the optimal principal P^*. Since there is only one bond in place there is in this case no room for debt agency problems and an equity maximizing strategy is equivalent to an value maximizing strategy. The optimal principal can therefore be determined by maximizing the value of the sum of all corporate claims i.e. by solving the problem

$$P^* = \arg\max_{P} \{D(P) + E(P)\} \tag{1.8}$$

Since the legal setup for the company's tax treatment creates the mention cross dependencies and the equations determining D and E contain special functions, it is not possible to solve the above problem explicitly. One has to rely on numerical techniques in order to obtain P^*.

1.2.2 Acquisitions and structured debt contracts in this model

1.2.2.1 Acquisitions and their implementation

In this section I introduce acquisitions and structured debt contracts. At $t = 0$ it is assumed that the company has already an asset 1 defined by the pair (μ_1, σ_1) on its asset side of the balance sheet. On the liability side it has a debt contract with principal P_1^* and equity. Its capital structure is optimally selected according to the objective function in equation 1.8.

At $t = 0$, an acquisition becomes available - i.e. the company may invest in a second asset, which is defined by the pair (μ_2, σ_2) and correlation $\rho_{1,2}$ to the incumbent asset 1. The new investment opportunity set is therefore defined by the five parameters $(\mu_1, \sigma_1, \mu_2, \sigma_2, \rho_{1,2})$. It is assumed that assets are traded at their unlevered after tax value. The company may finance the acquisition by a mix of straight debt and equity i.e. the company may issue a second bond with principal P_2. The optimal principal P_2 of the new bond depends on the incumbent contract as well as on the objective function which may either be value maximizing or equity maximizing.

1.2.2.2 Debt contracts in the extended model

In the following I introduce the debt contracts listed in the introduction. I will define the contracts and give pricing formulas for the market value of the structured debt contracts after the acquisition, the new straight debt contract and the equity. These equations are the extended versions of equations 1.6 and 1.7. It was assumed that assets are additive and normally distributed. As a consequence of this, for contracts which do not require that the company places the assets in bankruptcy remote entities, the asset side of the company may be treated as one synthetic asset 3, which is described by the parameter pair (μ_3, σ_3), where $\mu_3 = \mu_1 + \mu_2$ and $\sigma_3 = \sqrt{\sigma_1^2 + \sigma_2^2 + 2\sigma_1\sigma_2\rho_{1,2}}$.

1.2.2.2.1 Unsecured straight bond

In this model, an unsecured straight bond is a bond with principal P_1, which is not specifically secured with the asset side of the company. This means that the bondholder's claim has no priority over other debt claims when the liquidation proceeds are distributed. This is the first of the so called *priority principles* of Schwartz (1989) that the current United States Bankruptcy Code as well as the Swiss Bankruptcy Code follow. This principle essentially means that the incumbent bond and the new bond are pari passu when liquidation proceeds are distributed. The zero tax barrier is at

$$X_{ZT} = P_1^* - D_1(P_2) + P_2 - D_2(P_2) \tag{1.9}$$

and the default barrier at

$$X_d = P_1^* + P_2 + \frac{\tau}{1-\tau}(D_1(P_2) + D_2(P_2)) \tag{1.10}$$

Then the market value of the incumbent and the new debt contracts are

$$D_1(P_2) = \frac{1}{(1+r_f)}\left(P_1^*\left(1 - \Phi\left(\frac{X_d - \mu_3}{\sigma_3}\right)\right) + \frac{P_1^*(1-\alpha-\tau)}{P_1^* + P_2}G(0, X_d, \mu_3, \sigma_3)\right) \tag{1.11}$$

and

$$D_2(P_2) = \frac{1}{(1+r_f)}\left(P_2\left(1 - \Phi\left(\frac{X_d - \mu_3}{\sigma_3}\right)\right) + \frac{P_2(1-\alpha-\tau)}{P_1^* + P_2}G(0, X_d, \mu_3, \sigma_3)\right) \tag{1.12}$$

The first term is just the repayment of the principal in case the company does not default. In default, which is the second term, the bondholders are pari passu, i.e. from the liquidation proceeds they both receive a share that is proportional to the ratio of their own principal over total outstanding liabilities. The market value of the equity is then

$$E(P_2) = \frac{1}{(1+r_f)}\left((1-\tau)G(X_d,\infty,\mu_3,\sigma_3) - (P_1 + P_2 - \tau X_{ZT})\left(1-\Phi\left(\frac{X_d-\mu_3}{\sigma_3}\right)\right)\right) \quad (1.13)$$

The equation for the equity has only a non-default term. It receives all proceeds form the assets minus the debt payments plus the tax shield if the company is solvent.

1.2.2.2.2 Senior secured straight bond

In this model, a senior secured bond is a bond with principal P_1 that is secured with the company's assets. It has priority over a potential new bond issued by the company, meaning when liquidation proceeds are distributed, this bond is served first. This is the third principle of the priority principles in Schwartz (1989). The new junior bond only receives liquidation proceeds if the senior bond is fully served. As a consequence of that clause, one needs an additional barrier that indicates - given the company has defaulted - at what level the senior bond is fully served and thus the junior bond receives liquidation proceeds. One may view this as a synthetic default barrier for the incumbent senior bond, since every state above this barrier yields a payoff for that bond that is equivalent to a state above the default barrier. This barrier X_{SD} is at[12]

$$X_{SD} = \frac{P_1^*}{1-\tau-\alpha}$$

The distribution of liquidation proceeds is the only difference between an unsecured straight bond and a senior secured straight bond. This implies that the equations for the default barrier, the zero tax barrier and the fair market value of the equity remain the same i.e. equations 1.9, 1.10 and 1.13 remain valid for this contract. The fair market value of the incumbent senior bond after the acquisition is

$$D_1(P_2) = \frac{1}{(1+r_f)}\left(P_1^*\left(1-\Phi\left(\frac{X_{SD}-\mu_3}{\sigma_3}\right)\right) + (1-\alpha-\tau)G(0,X_{SD},\mu_3,\sigma_3)\right) \quad (1.14)$$

which looks like a conventional bond whose default barrier is at the synthetic default barrier. The fair market value of the new junior bond is

[12] For more convenient pricing equation, one would like to have the following ordering between the new synthetic default barrier and the real default barrier: $X_{SD} \leq X_d$. Given the form of the default barrier, this is satisfied by the condition $\frac{\alpha}{1-\alpha-\tau}P_1^* \leq P_2 + \frac{\tau}{1-\tau}(D_1 + D_2)$ - which essentially means, that α should not be too large. If α would be very large then the gap between the company as a going concern and the company in liquidation could be large enough that there exists a state where the company as a going concern has enough proceeds from the assets to pay off both bonds, but in liquidation not enough to serve the senior bond. From here on forward I will assume, that α is small enough that such a state does not exists.

$$D_2(P_2) = \frac{1}{(1+r_f)}\left(P_2\left(1-\Phi\left(\frac{X_d-\mu_3}{\sigma_3}\right)\right)+(1-\alpha-\tau)G(X_{SD},X_d,\mu_3,\sigma_3)\right)-$$

$$\frac{1}{(1+r_f)}\left(P_1^*\left(\Phi\left(\frac{X_d-\mu_3}{\sigma_3}\right)-\Phi\left(\frac{X_{SD}-\mu_3}{\sigma_3}\right)\right)\right) \quad (1.15)$$

The first term is the value given the company does not default and the second and third term are *leftovers* from the liquidation proceeds that the junior bond receives in default.

1.2.2.2.3 Callable bond

A callable bond in this model is an incumbent bond with principal P_1, that the company may call at time $t = 0$ at pre-acquisition fair market value[13]. The callable bond allows the company to have a *restart* or *reset* of its capital structure i.e. it may call the bond prior to the acquisition and refinance it together with the acquisition bond. What kind of impact that has on the value of the equity, I will discuss in the next section. Insofar as the pricing equations are concerned, they are essentially equivalent to the base case, only that the asset side of the balance sheet is now larger and contains the synthetic asset 3. Equations 1.6 and 1.7 remain the pricing equations for the fair market values of debt and equity in the scenario where a callable bond has been redeemed and refinanced.

1.2.2.2.4 CLO

A CLO is a bond with principal P_1 that is secured with a specific asset of the issuing company. To protect this asset from a potential default of the issuer on a combined level, the company places the asset in a bankruptcy remote entity or simply in a subsidiary[14]. The company then levers the asset through this subsidiary. The result is a debt contract that is backed by a specific bankruptcy remote asset. After the acquisition there are two CLOs, one backed with asset 1, the other backed with asset 2. As a consequence of that, the fair market value of the debt contracts after the acquisitions as well as of the equity stakes may be valued with equations 1.6 and 1.7.

1.2.2.2.5 Convertible bond

A convertible bond is a bond that combines an unsecured straight bond with an option on

[13] Usually, calling a bond involves paying a penalty fee, but within the scope of this model, such a penalty fee would be arbitrage.

[14] Strictly spoken, just placing assets in a subsidiary does not make them a priori bankruptcy remote. Paragraphs $35-45$ of FAS 140 detail the conditions that have to be (jointly) fulfilled by a subsidiary to qualify for the status of a *qualifying special purpose entity*. This status is necessary to issue CLOs. The nature of the technicalities in FAS 140 are important but beyond the scope of this paper. It will just be assumed that they are fulfilled.

some of the company's equity. In this model, it is a bond with principal P_1 and the option to convert it into a fraction λ of the company's equity. If λ - the conversion ratio - is equal to zero, the conversion feature is void and the bond is equivalent to an unsecured straight bond. The convertible bond is - as a result of the conversion privilege - assumed to be junior to a potential new bond i.e. it contains a subordination clause. The conversion option is assumed to be dilution protected. Also - given the conversion option is exercised - the hypothetical tax shield provided by the convertible bond before it is converted is lost as payments on equity are not tax deductible.

So far, all the different debt contracts had the same pricing equations prior to the acquisition, when the company has only one asset and one incumbent bond on its books. They were presented in equations 1.6 and 1.7. Because of the conversion option, the convertible bond does not share these equations. The default bound and the zero tax bound as per equations 1.1 and 1.3 remain the same. The bondholder naturally exercises the conversion option optimally i.e. one has to define a conversion bound. This bound is at the point, where the value of the company's assets is high enough to make the hypothetical equity stake of the bondholder worth more than the principal received when the bond matures[15]

$$X_{CV} = \frac{P_1}{(1-\tau)\lambda}$$

The fair market value of a convertible bond prior to the acquisition is then

$$D(P_1) = \frac{1}{(1+r_f)^T}\left((1-\tau)\lambda G(X_{CV}, \infty, \mu_1, \sigma_1)\right) +$$

$$\frac{1}{(1+r_f)^T}\left(P_1\left(\Phi\left(\frac{X_{CV}-\mu_1}{\sigma_1}\right) - \Phi\left(\frac{X_d-\mu_1}{\sigma_1}\right)\right) + (1-\alpha-\tau)G(0, X_d, \mu_1, \sigma_1)\right) \tag{1.16}$$

where the first term is the value if the bond is converted, the second term the value when the bond is not converted and the third term the value when the company defaults. The fair market value of the equity stake is

$$E(P_1) = \frac{1}{(1+r_f)^T}\left((1-\tau)(1-\lambda)G(X_{CV}, \infty, \mu_1, \sigma_1)\right) +$$

$$\frac{1}{(1+r_f)^T}\left((1-\tau)G(X_d, X_{cv}, \mu_1, \sigma_1) - (P_1 - \tau X_z)\left(\Phi\left(\frac{X_{CV}-\mu_1}{\sigma_1}\right) - \left(\frac{X_d-\mu_1}{\sigma_1}\right)\right)\right) \tag{1.17}$$

[15] A problem of ordering similar to the one in footnote 12 arises here: One of course wants an ordering $X_d < X_{CV}$. For that purpose the condition $\frac{P_1}{X_d} > \lambda$ should be satisfied i.e. the conversion ration should not be to high. From here on forward I will assume that this is the case.

That is the situation prior to the acquisition. Again the company finances the unexpected acquisition with a mix of debt and equity. As already mentioned, it is assumed that the bond part of the incumbent convertible bond is junior to the acquisition bond. The principal of the incumbent convertible bond is optimally determined given the pre acquisition assets of the company using equation 1.8. P_2 denotes again the principal of the acquisition bond.

As a consequence of the combination of an incumbent convertible bond and a new bond, a number of bounds are needed. These are presented in the list below

- A conversion bound $X_{CV} = \frac{P_1^* + P_2\lambda - \lambda\tau(P_2 - D_2(P_2))}{\lambda(1-\tau)}$
- A zero tax bound when the conversion option has been exercised $X_{ZT_2} = P_2 - D_2(P_2)$
- A zero tax bound when the conversion option has not been exercised $X_{ZT_1} = P_1^* - D_1(P_2) + P_2 - D_2(P_2)$
- A default bound $X_d = P_1^* + P_2 + \frac{\tau}{1+\tau}\left(D_1(P_2) + D_2(P_2)\right)$
- A synthetic default bound for the acquisition bond[16] $X_{SD} = \frac{P_2}{1-\alpha-\tau}$

The fair market value of the incumbent convertible bond is then

$$D_1(P_2) = \frac{1}{(1+r_f)^T}\left(\lambda(1-\tau)G(X_{CV}, \infty, \mu_3, \sigma_3) - \lambda P_2\left(1 - \Phi\left(\frac{X_{CV} - \mu_3}{\sigma_3}\right)\right)\right) +$$

$$\frac{1}{(1+r_f)^T}\left(\lambda\tau X_{ZT_2}\left(1 - \Phi\left(\frac{X_{CV} - \mu_3}{\sigma_3}\right)\right) + P_1^*\left(\Phi\left(\frac{X_{CV} - \mu_3}{\sigma_3}\right) - \Phi\left(\frac{X_d - \mu_3}{\sigma_3}\right)\right)\right)$$

$$\frac{1}{(1+r_f)^T}\left((1-\alpha-\tau)G(X_{SD}, X_d, \mu_3, \sigma_3) - P_2\left(\Phi\left(\frac{X_d - \mu_3}{\sigma_3}\right) - \Phi\left(\frac{X_{SD} - \mu_3}{\sigma_3}\right)\right)\right) \quad (1.18)$$

The first three terms reflect the situation when the bond is converted, the fourth term the situation when the bond is not converted and the fifth and sixth term the situation when the company defaults. The fair market value of the new bond is

$$D_2(P_2) = \frac{1}{(1+r_f)^T}\left(P_2\left(1 - \Phi\left(\frac{X_{SD} - \mu_3}{\sigma_3}\right)\right) + (1-\alpha-\tau)G(0, X_{SD}, \mu_3, \sigma_3)\right) \quad (1.19)$$

[16]This bound is necessary because it is assumed that the new bond is senior to the convertible bond.

The fair market value of the equity stake after the acquisition is

$$E(P_2) = \frac{1}{(1+r_f)^T}\left((1-\lambda)\left((1-\tau)G(X_{CV},\infty,\mu_3,\sigma_3) - (P_1 - \tau X_{ZT_2})\left(1-\Phi\left(\frac{X_{CV}-\mu_3}{\sigma_3}\right)\right)\right)\right) +$$

$$\frac{1}{(1+r_f)^T}\left((1-\tau)G(X_d,X_{CV},\mu_3,\sigma_3) - \left(P_1^* + P_2 - \tau X_{ZT_1}\right)\left(\Phi\left(\frac{X_{CV}-\mu_3}{\sigma_3}\right) - \Phi\left(\frac{X_d-\mu_3}{\sigma_3}\right)\right)\right) \tag{1.20}$$

The first line represents the equity value if the conversion option is exercised while the second line represents the equity value if the conversion option is not exercised.

1.2.2.3 The optimal financing of the acquisition

The capital structure to implement the acquisition may either maximize the company's total value or only maximize the company's equity value. Prior to the acquisition with only one bond, these two strategies are equivalent - anything else would be arbitrage. With an acquisition after the incumbent bond has been issued, these two strategies are not necessarily equivalent. The reasons for that is that the acquisition allows the equityholder to alter the capital structure subsequently to his advantage. I will address this in more detail in section 1.3. Equation 1.21 - which is the two bond equivalent to equation 1.8 - states the problem to obtain the optimal principal P_2^* for a *value maximizing* post acquisition capital structure.

$$P_2^* = \arg\max_{P_2}\{D_1(P_2) + D_2(P_2) + E(P_2)\} \tag{1.21}$$

The objective function for the *equity maximizing* capital structure is to maximize the equity's net advantage of the acquisition i.e. the equityholder's value added minus the equityholder's capital outlay to the financing of the acquisition which is denoted by $e(P_2)$. The capital outlay is the fraction of the costs[17] of the acquisition $K = \frac{(1-\tau)}{(1-r_f)^T}\int_0^\infty X_2 dF_{X_2}$, that the equityholder bears i.e. $e(P_2) = K - D_2(P_2)$. The equityholder's trade off is then

$$P_2^* = \arg\max_{P_2}\{E(P_2) - e(P_2)\} = \arg\max_{P_2}\{E(P_2) - (K - D_2(P_2))\} \tag{1.22}$$

[17]Remember that assets are assumed to be traded at their unlevered after tax value.

1.3 Implications and Results

This section presents the implications and results obtained from the model described in the last section. These implications and insights help to answer the questions posed in the introduction. They are also compared to anecdotal evidence to provide a link to what happens on the financial market.

To visualize this more clearly, I introduce some measurements of gains and losses that the equityholder of the bondholder may achieve or suffer as a result of the acquisition. The *debt value added/loss* (DVA), is the gain or loss in value that the incumbent bondholder achieves or suffers as a result of the acquisition. The *equity value added/loss* (EVA) is the net[18] gain or loss in value that the equityholder makes or suffers as a result of the acquisition. The *debt agency costs* (DAC) are the difference between the debt value added/loss after the acquisition under a value maximizing capital structure and the debt value added/loss after the acquisition under an equity maximizing capital structure. The *equity agency gains* (EAG) is the difference between the equity value added/loss under a value maximizing capital structure after the acquisition and the equity value added/loss under an equity maximizing capital structure after acquisition. The *welfare loss* (WL) is the difference between the over all value created/lost by the acquisition after an equity maximizing capital structure is implemented versus a case where a value maximizing capital structure is implemented.

As I mentioned earlier, there are only numerical solutions to the model, there is no closed form solution. It is therefore necessary to assign values to the parameters. Table 1.1 presents the parameters that will have the same value throughout the paper. The assets in this model have all the same expected present value and are traded in bits having a value of 100. The annual volatility of the incumbent asset 1 is fixed as well. The value assigned to this parameter is set according to the empirical analysis of Schaefer and Strebulaev (2008) to the average annual asset volatility of a BBB rated company. The conversion ratio of the convertible bond is also fixed. As mentioned in footnote 15, the conversion ratio should not be too high. But it should also not be too low because if $\lambda \to 0$, the conversion option is void and the convertible bond degenerates an unsecured junior bond. The value in table 1.1 is a good trade off between the two issues.

INSERT TABLE 1.1 ABOUT HERE

Table 1.2 presents values for parameter that are fixed unless they are the object of interest. The correlation is a value that is not extreme in one direction or the other direction. The

[18] *Net* gains or losses for the equityholder means gains/losses after accounting for the fresh capital that had to be injected.

bankruptcy costs are chosen according to the Leland (2007) paper. In that paper the value is selected to meet observed recovery rates. In other papers analysing capital structure issues numerically, similar values are used e.g. in Leland (1998) or a bit lower in Hennessy and Whited (2007). The tax rate is an average value for both, the United States and Switzerland. The same value is used in Leland (1998) and Leland (2007). Time to maturity is set to an average as well, in Leland (2007) it is mentioned that this is close to the estimated average corporate bond maturity. For that maturity a comprehensive range of iTraxx and CDX indices exists and they are relatively liquid.

INSERT TABLE 1.2 ABOUT HERE

1.3.1 The risk perspective

1.3.1.1 Unsecured straight bond

The functions of interest in this analysis are the functions that express a shift in one of the stakeholder's value, agency cost or welfare loss. With the earlier mentioned term perspective I refer to a mesh, drawn over an appropriate two dimensional grid. For instance figure 1.1 presents the risk perspective of the DVA under a value maximizing capital structure i.e. the DVA drawn over a grid of the annual volatility of the acquired assets (σ_2) and the correlation between the incumbent and the acquired assets (ρ). I offer a perspective on risk, bankruptcy costs, taxes. For the risk perspective of the unsecured straight bond, the results are collected in figure 1.1, using the model introduced in the last section.

Figure 1.1(a) and figure 1.1(b) present the DVA under a value and an equity maximizing post-acquisition capital structure. The north corner of the σ_2/ρ-plane is the point with lowest risk i.e. low volatility and no correlation, the south corner is the point with the most risk i.e. high volatility and almost perfect correlation. What is observed is the following: An increase in the company's asset volatility leads to a loss for the bondholders - having a concave claim - and to a gain for the equityholder - having a convex claim. This holds true under a value maximizing capital structure as well as under an equity maximizing capital structure. The model is here consistent with classical asset substitution. The reverse holds true for the EVA presented in figure 1.1(c) and figure 1.1(d). Since the equityholder's claim is convex, the result is that the riskier the acquisition is, the more the equityholder gains.

INSERT FIGURE 1.1 ABOUT HERE

What is also visible for both - the DVA and the EVA - the losses and gains respectively are more pronounced for the equity maximizing leverage choice. That can be seen more detailed in figures 1.1(e) and 1.1(f). DAC and EAG are both different from zero and the agency gains/loss increase with risk. The equityholder may extract agency gains from the bondholder, not only through asset substitution but also through a dilution of the bondholder's claim. He may do that by using the change in the company's capital structure triggered by the acquisition to accumulate excess leverage[19]. This is presented in the special figure 1.1(h), which illustrates the difference in post acquisition leverage ratio of a value maximizing and an equity maximizing capital structure. The difference is positive and increasing with risk. It is classical debt dilution that the model is implying here.

The agency gains are more pronounced the riskier the acquisition is, because then debt dilution may be reinforced with asset substitution. The order of magnitude of the dilution is between 2% and 4%. This is a bit more than what was implied by Leland (1998) for an unsecured straight bond. The question is, whether this is a figure to worry about? In the much publicised *Marriot Case* of 1993, the incumbent bondholders lost - according to Parrino (1997) - about 4% of their value. As a consequence of the incumbent bondholder's pressure, the spin off plan was revised to reduce their loss. So the model seems to imply an order of magnitude that is relevant to investors, but still reasonable enough to find anecdotal evidence.

Another example to demonstrate how this problem of debt dilution is observed in practice: In 2001 the US company *Martin Marietta Materials* took over *the fellow US company Meridian Aggregates.* Martin Marietta was more focused on chemical building materials, while Meridian was an aggregates and cement company. So there is certainly some correlation between the two businesses, since both company's belong to the sector of building materials. This acquisition led to an increase in asset volatility as well as to an increase in leverage which eventually led to a decrease in interest coverage. As a result of that this led to a weakening of the *existing bondholder protection measures [namely the interest rate coverage]* and to a downgrade of Martin Marietta's commercial paper program by Fitch.[20] This is exactly what is implied by the model in this paper.

The welfare loss is very low as an absolute figure, but it is also increasing with the riskiness of the acquisition. This is because of the bondholder's convex claim, the claim is the more diluted, the risker the acquisition is and asset substitution by definition implies that the company's

[19]Excess leverage means here the additional leverage beyoned the value maximizing optimum.

[20]Source: "Fitch Lowers Martin Marietta'S Cp Rating", article in Business Wire, Date: Thursday, March 8, 2001.

business risk is increased. The agency costs and thus the welfare loss is the worst, the more risky the acquisition is.

1.3.1.2 Senior secured bond

The senior secured bond is a bond, where the bondholder's claim is senior to any potential new bondholder. What happened above with the unsecured straight bond was that it was diluted either by taking on more debt that was ranked pari passu (debt dilution) or by increasing the risk of the company's assets (asset substitution) or even both. But no matter what effect was responsible for the bondholder's agency loss, the reason why it happened was a dilution of the bondholder's claim. It is important to note that it is not the entire claim that was diluted, but only the embedded claim on liquidation proceeds in case of a bankruptcy. This is exactly where the seniority clause becomes effective.

Figure 1.2(a) illustrate this. The DVA of an incumbent bondholder with a senior claim is on the entire grid positive. This has two reasons: The incumbent bondholder is legally protected against direct debt dilution through the seniority clause. On top of that, there is no room for indirect dilution through asset substitution. The company is doing an acquisition, which means that it is expanding its asset base. So even if the incumbent assets are expanded with extremely risky assets, there are - in the event of a default, which is where the unsecured claim was vulnerable - still more assets to liquidate and thus in probabilities more liquidation proceeds to satisfied the senior claim.

INSERT FIGURE 1.2 ABOUT HERE

The only way to dilute a senior claim would be to siphon assets out of the company i.e. to reduce the asset base. This is sometimes called *asset dilution.* For a secured bond that would be a breach of contract - the assets to be spun off are pledge as a collateral - and it is assumed that this does not happen. But it is this what the bondholders were concerned about in the Marriot spin off of 1993. There the equityholders were about to reduce the asset base of the company and thus reducing the value of the incumbent bondholder. Empirical evidence in Maxwell and Rao (2003) affirms more generally, that spin-offs are potentially diluting for incumbent bondholders.

The shape of the DVA however is similar to the one of an unsecured bond: The less risk, the more is there to gain for the incumbent senior bondholder. The explanations for that is that the senior bond's payoff is still - despite the seniority clause - concave and thus the bond's value is decreasing in risk. The more risky the assets are, the more likely is default and thus the value added of the incumbent bond must be decreasing in risk. The overall conclusion is therefore that a seniority clause protects the incumbent bondholder almost perfectly from agency costs caused by acquisitions, but it does not change the shape of the claim, it is still concave.

The equityholder faces a situation that is altered compared to the situation with the unsecured bond because of an agency problem: This is presented in figure 1.2(b). The equityholder has still a claim which is increasing in risk and thus for most of the grid, the best acquisition for him is one that is very risky. But an additional effect is now more clearly visible. The equityholder has two ways in which he may increase the value of his claim through an acquisition: One is by relying on the convexity of his claim and thus increasing the risk - a positive[21] risk effect. The other is in reducing his share of the acquisition costs i.e. reducing the amount of capital he has to contribute to the acquisition - a capital effect.

Why would the capital outlay matter? This capital effect is related to the debt overhang problem first noted in Myers (1977) and is an agency problem as well: In the standard debt overhang problem, the face value of the incumbent debt is higher than the expected payoff of the assets and as a consequence of that, an additional investment by the equityholder would - at least in part - be absorbed by the incumbent bondholders. The debt is then called *underwater.* The bondholder's DVA in figure 1.2(a) is decreasing in risk i.e. the lower the risk the more the bondholder profits form the value added created by the acquisition. Thus the senior bondholder is profiting from the equityholder's capital outlay without contributing to it as it increases the collateral base of the company. So in some sense the incumbent senior bondholder is the agency player here as free rides on the acquisition, an effect similar to debt overhang.

In the most part of the grid in figure 1.2(b), the risk effect is dominating. Towards the west corner of figure 1.2(b), the capital effect starts to dominate and thus the EVA is decreasing instead of increasing in risk. This is because leverage is decreasing with risk and the best choice for the equityholder in that region is to lever the acquisition as much as possible and thus reduce the capital outlay. This may be surprising but it is perfectly rational. In the middle of the grid, neither effect plays and the company finds itself in a debt overhang problem. The capital effect influences an unsecured bond as well. However, with an unsecured bond debt dilution is more effective than the capital effect.[22]

There is some anecdotal evidence on that: In 2007, the Mexican cement company *Cemex* took over the Australian cement and building materials company *Rinker.* Although Rinker was

[21] Positive for the equityholder.

[22] In figure 1.1(c) the capital effect is visible towards the west corner, in figure 1.1(d) the risk effect dominates so much, that the capital effect disappears.

from Australia, up to 80% of its sales were generated in North America. Cemex was already present in the North American market, Rinker's geographical presence was very different from Cemex's presence. At this point in time, the North American market was thought to be a low risk market for building materials. Moreover, the market has still strong regional difference i.e. the regions are not very correlated.[23] Overall the acquisition was not expected to increase risk. In line with the implications of this model, the capital effect was dominating and the Rinker acquisition was essentially a buyout, mostly funded with debt.[24].

The reverse happened two years later: Holcim also announced in 2009 that it will take a substantial stake in the Chinese cement company Huaxin Cement[25]. Holcim was not really present then in China i.e. this was - particularly after the meltdown in the emerging markets construction sector in 2008 - a risky acquisition. This transaction was - in line with the insights that the model in this paper delivers - financed with a capital increase in Holcim.

In terms of quantity, the bondholder's value shift that occurs as a result of the acquisition, is always positive. He may gain $1\% - 5\%$ on the acquisition. This is remarkable and may give room to capital structure arbitrage around mergers and acquisitions. The presence of a seniority clause reduces the gains for the equityholder. Which were with an unsecured bond at $1\% - 6\%$ with a value maximizing capital structure and $2\% - 9\%$ with an equity maximizing capital structure - to below $0\% - 2.5\%$ and leaves no room for agency gains through acquisitions. Since there is no room for agency, there is also no room for welfare loss.

1.3.1.3 Callable bond

Textbooks like Brealey et al. (1981) and sales presentation often suggest that callable bonds are essentially issued because of two reasons: First, in order to give the issuer the option to refinance the bond if the reference interest rate significantly falls or second, to give the issuer the option to refinance the bond if the company's rating improves. Consequently, high yield bonds are often callable. The first motive is not relevant in this paper. In this model, credit spreads solely depend on the company's risk profile and on the company's leverage. The risk free rate is not stochastic. The second motive is not relevant as well, since it is only a two period model.

There is however a third, new rationale for callable bonds: In a situation with an incumbent senior bond, the DVA was always positive i.e. the seniority clause forces the equityholder to

[23]This still holds true within the United States. The effect on residential property price of the subprime meltdown was very heterogenous. While prices in California or Florida were heavily down, Texas property still generated very low positive returns.
[24]Source: Corporate Presentations of Cemex.
[25]Source: Company press release, June 15, 2009.

share the value added of an acquisition with the incumbent bondholders. The equityholder leaves money on the table. This is the reason why a right to redeem the bond early may be valuable to the equityholder, even in the absence of the usual rationales for embedded options in corporate bonds. They allow the equityholder to refinance an incumbent bond with a new bond covering company's entire demand for external capital. This new bond can then be sold at fair value, instead of leaving money on the table for the incumbent bondholders. It allows the equityholder to have a *fresh start* and thus implement an exactly optimal capital structure.

Since calling the bond implies that the entire capital structure is revised and a new, large bond is issued at fair value, there is no room for agency here. What is presented in figure 1.3(a) is only the EVA of an acquisition that has an optimal post acquisition capital structure with only one straight bond and equity. The other figures are irrelevant, since the incumbent bond is refinanced.

INSERT FIGURE 1.3 ABOUT HERE

It may be surprising that the optimal acquisition would be one in the west corner of figure 1.3(a) i.e. with low risk. There are again the capital effect and the risk effect that enter the trade off here. The equity claim is still convex and even the assets on a company's books are in some sense a convex claim, since the company is protected by limited liability. For most of the grid in figure 1.3(a), the capital effect is dominating. But as is also visible, at about $\sigma_2 = 0.3$ the slope of the EVA plane is reversed and - if the σ_2-axis would be widened - further east, in the region $\sigma_2 \in [0.4, 0.5]$ the EVA would surpass the EVA level in the west corner. The risk effect only starts to dominate this trade off at a high level of asset volatility and is the dominant value creator for an almost unrealistic level of asset volatility.[26]

Not only enables an embedded call option the equityholder to claim all the value added of an acquisition, it might even be a way of signalling that the company is sorting out hypothetical agency conflicts. Or it might also be a form of precaution against potential allegation that the company tries to extract agency rents. It is occasionally observed on the market that debt is refinanced after an acquisition. When the Swiss duty-free shop operator Dufry took over the American Hudson Group in September 2008, it was expanding into a new region namely the United States and into the less concentrated duty-paid business. Although the acquisition was financed primarily with equity, the entire debt of Dufry and Hudson was refinanced by a new debt facility, and thus leaving no money on the table for the incumbent Dufry debt holders.[27]

[26] This might to some extend be driven by the static structure of the model.
[27] Source: H1-08 analyst's presentation of Dufry.

1.3.1.4 CLO

A CLO is a bond that is secured with a specific asset, placed in a bankruptcy remote entity. A CLO has an advantage for both stakeholder: Since the assets are placed in separate entities, one entity is not influenced by the other and thus DVA is zero over the entire grid and is not plotted. The bondholder is therefore protected against every possible form of agency mentioned so far, debt dilution, asset dilution and asset substitution. So from the bondholder's perspective, this form of debt contract makes sense, when agency costs are a potential issue. As it was mentioned earlier, this is especially the case when risk is high.

The equityholder has an advantage as well: Since the acquisition is brought into a new entity, the equityholder may reduce that he potentially leaves money on the table. The EVA surface for the CLO is presented in figure 1.3(b). Because the acquisition is held by a subsidiary rather than the original company, the correlation ρ with the incumbent assets does not influence the optimal capital structure of the new subsidiary and the default risk is separated.

As it is visible in figure 1.3(b), a CLO make sense for the equityholder, if risk is either very high or very low. On the low risk side, the equityholder may reduce the money left on the table. On the high risk side, the equityholder may reduce financing costs through a separation of the bankruptcy risk. He may also take advantage of additional limited liability as this was discussed in Leland (2007).

The present form of debt contract was and is still common for companies in businesses which are capital intensive. Examples would be energy upstream, airlines or cement making. Also they were extensively used to refinance all kinds of mortgages.

Another example for the use of securitization would be the now bankrupt Enron. Enron made extensive use of securitization before its default. It financed its merchant assets to a large extend with debt through various subsidiaries. In 1999 Enron North America[28] pooled a group of loans to its merchant assets in the United States into a trust and sold securities against the trust as Collateralized Loan Obligations (CLO).[29] There is no information what kind of loans Enron pooled in that CLO, but Enron's new merchant assets were - compared with the original gas pipeline and gas wholesale business - fairly risky.[30] At the time the CLO was issued Enron was heavily acquiring risky assets. This CLO was therefore an ideal solution to avoid agency

[28] A subsidiary of Enron, holding most merchant assets in the United States.

[29] Enron did a series of transaction with loans that were at least questionable if not illegal. This CLO transaction did - according to Powers et al. (2002) - NOT belong to this group.

[30] Jeffrey Skillings is heard saying *We like risk, because you make money by taking on risk.* in the movie *Enron, the smartest guys in the room* of 2005.

conflicts[31] in the future with the bondholders - on top of that - leaving no money on the table for bondholders to other project not included in the CLO.

1.3.1.5 Convertible bond

In textbooks, convertible bonds are often praised as *sweetened debt* i.e. as an instrument to reduce credit spreads by allowing the bondholder to profit from the upside. This is undoubtedly one feature of convertible bonds, but as odd as it may seem, in the base case of this model, i.e. prior to an acquisition, it is inefficient to issue a convertible bond. This is because exercising the conversion option destroys the tax shield. This has the consequence, that it pushes up the conversion bound.

The DVAs of the convertible bond are presented in figures 1.4(a) and 1.4(b) for a value maximizing capital structure as well as for an equity maximizing capital structure. The incumbent bondholder has now two parts that drive the value of his position. One is the embedded conversion option, whose payoff is convex in shape, the other is the bond part of the convertible bond whose payoff is concave in shape. The shape of the DVAs in figures 1.4(a) and 1.4(b) is similar to a standard bond i.e. the bond part of the convertible bond is driving the bondholder's added value in shape. But by comparing figure 1.4(a) to figure 1.1(a), it becomes evident that the shape of the DVA surface is similar, the level of the convertible bonds DVA surface is however different. This is the influence of the conversion option.

INSERT FIGURE 1.4 ABOUT HERE

The welfare loss, that is illustrated in figure 1.4(g), is with 1.8% to 2.5% remarkable in size. Conversion options are therefore not only vulnerable from the bondholders perspective, but may also be inconvenient for a potential social planner. Striking is the shape of the welfare loss surface. It is not the worse the more risk there is but the worst region is somewhere in the middle.

Looking at the DVA in figure 1.4(b) as well as at the DAC in figure 1.4(e) it is also clear, that the convertible bond is vulnerable to agency issues. A convertible bond is a hybrid financing instrument, an as mentioned earlier. I assume that the additional straight debt can be issued senior to the convertible bond.

The first agency problem is equivalent to the one with the unsecured straight bond. The equityholder may engage in diluting the incumbent bondholder's claim by issuing straight debt. He can reinforce that with asset substitution i.e. by doing a risk acquisition. This is the first

[31] Remember, most of Enron's story is about corporate governance or agency issues between Enron and its shareholders and not between Enron and its creditors.

reason why a convertible bond in this model is vulnerable to agency problem.

The second agency problem is related to the conversion option and is again an agency problem that is related to the Myers (1977) the debt overhang problem: The equityholder has no incentive to put up additional capital for the company. Through the embedded conversion option, the incumbent bondholders would profit from a hypothetical investment that the equityholder helps to finance. A convertible bond is underwater when the conversion option dominates the value of the bond. This problem is reinforced by presence of the anti dilution clause. The conversion option is written on non diluted equity whereas the equityholder holds diluted equity. The convertible bond suffers in a way a *constant debt overhang problem.*

This constant debt overhang or simply underinvestment problem of the equityholder is illustrated in the special figures 1.4(h) and 1.4(i). They illustrate the surface of leverage ratios of the company after the acquisition for a value maximizing capital structure in figure 1.4(h) and for an equity maximizing capital structure in figure 1.4(i). The leverage ratio in figure 1.4(i) is higher across the entire surface than in figure 1.4(h). This reflects exactly the equityholder's lack of incentive to contribute additional capital to the company. The equityholder tries to neutralize the debt overhang problem with excess leverage. The potential agency losses that are illustrated in figure 1.4(e), are remarkable in size, namely between 8% and 18%. Investors in convertible bonds therefore have to monitor the company's financing and M&A activities closely.

The equityholder loses under a value maximizing capital structure on every acquisition on this grid as illustrated in figure 1.4(c). This is a direct consequence of the convertible bond's debt overhang problem mentioned in the last paragraph. Under an equity maximizing capital structure, the equityholder may make rather large gains on acquisitions as illustrated in figure 1.4(d). About half of these gains are attributed to agency as illustrated in figure 1.4(f). All these surfaces are increasing in risk.

The market is well aware of the opportunities and problems that occur with convertible bonds in acquisitions. During the first half of 2009, the Australian uranium exploration company *Scimitar Resources* took over the fellow Australian metal and noble metal mining company *Jackson Minerals* to become *Cauldron Energy.* In the month where the acquisition took effect (June 2009), the company issued a new convertible bond to - among other things - redeem an existing convertible bond of Scimitar Resources.[32] The target is an exploration company, the acquisition can therefore be considered as a risky one.

In another example, Satcon Technology Corporation, a supplier of technology for alternative

[32]Source: Company Presentation 2009 of Cauldron Energy.

energy sources announced in 2007 that it will *accelerate its growth in the alternative energy market* which meant to growth through acquisitions. At the same time they announced that they would raise new external capital under their existing promissory notes program to finance there growth and to retire an existing convertible bond.[33]

These two examples show that the market is well aware of the agency problems that can occur with incumbent convertible bonds. In both cases, the agency loss seemed to be severe enough that both companies could not afford to jeopardize their reputation as a debtor by not buying out the incumbent bondholder prior to the expansion.

Sometimes convertible bonds even have voting rights on fundamental change i.e. they have some bargaining power. In 2005 the London-based *Crew Gold* took over the fellow London-based *Guinor Gold.* Both companies are gold mining and gold exploration companies. The acquisition was financed with debt as well as equity and was subject to approval of both, the incumbent Crew Gold equityholders as well the incumbent holders of a Crew Gold convertible bond. The Crew Gold convertible bond was protected against additional borrowing.[34]

A company issuing a convertible bond may signal, that it considers itself to be a mature company. In 2005 *Intel,* a former technology bubble stock issued a convertible bond. This was viewed by the market as a sign that the growth of Intel is coming to an end.

1.3.2 The bankruptcy costs perspective

With the earlier definition of a perspective, the bankruptcy costs perspective is a mesh over a grid of average annual asset volatility (σ_2) - in a way the master parameter - and bankruptcy costs (α). In some sense this is another risk perspective, since bankruptcy costs are hypothetical losses in default.

1.3.2.1 Unsecured straight bond

For an unsecured straight bond, this is presented in figure 1.5. For a value maximizing capital structure after the acquisition, figures 1.5(a) and 1.5(c) illustrate what one would expect: The higher the bankruptcy costs the less added value is there to gain. For the incumbent bondholder, this is a direct consequence of a high loss given default when bankruptcy costs are high. For the equityholder the consequence is indirect: The equityholder receives nothing in default, but the higher the bankruptcy costs, the larger are the financing costs. That is why the equityholder's

[33] Source: Company press release, Nov. 9, 2007.
[34] Source: Company press release, November 21, 2005.

EVA surface is similar in shape in the bankruptcy costs direction, but reversed in the asset volatility direction.

INSERT FIGURE 1.5 ABOUT HERE

What is more interesting is the equity maximizing post acquisition capital structure. At first - by only looking at the EVA in figure 1.5(f) and the EAG in figure 1.5(d) - it looks fairly standard. The more risk and the less bankruptcy costs, the more is there to gain in value and agency for the equityholder. But what is not reflected in these previous figures, but becomes evident in figures 1.5(e), 1.5(g) and 1.5(h), is that the equityholder is actually doing a trade off between agency gains and costs of additional leverage.

This is illustrated in the special figure 1.5(h), that plots the difference between the leverage ratio under a value maximizing capital structure and an equity maximizing capital structure. When the costs of bankruptcy are modest, then the costs of additional debt are modest and the equityholder may use this additional debt to dilute the incumbent debt claim. But with bankruptcy costs growing, the costs for the additional debt begins to raise and this limits the application of excess leverage for debt dilution. That is why the DAC surface in figure 1.5(e) has a kink in the middle. That's where the trade off starts to turn. Excess leverage becomes costly and only the costs of a smaller tranche of excess leverage are offset by agency gains. Since the excess leverage that is taken on for debt dilution is directly causing a welfare loss, the shape of the welfare loss surface in figure 1.5(g) shares the shape with the DAC surface in figure 1.5(e).

1.3.2.2 Senior bond

The results for a senior bond are reported in figures 1.6(a) and 1.6(b). For the senior bond, the DVA is decreasing in the level of bankruptcy costs. This is because bankruptcy costs have a direct negative effect on the senior bondholder's liquidation proceeds in case of a bankruptcy. What is rather surprising is the shape of the EVA surface, namely it is increasing in bankruptcy costs. The reason for that is again the debt overhang problem that the seniority clause bears. Since the equityholder's payoff is zero in default, assets with low bankruptcy costs only increase the value of the incumbent bondholders' claim through the seniority clause. This implies that the lower bankruptcy costs are the more pronounced is the debt overhang problem. This makes the equityholder better off in a regime with high bankruptcy costs and leads to the shape of the EVA surface.

INSERT FIGURE 1.6 ABOUT HERE

1.3.2.3 Callable bond and CLO

The results for a callable bond and a CLO are reported in figures 1.7(a) and 1.7(b). There is nothing unexpected to report for these two contracts. Both contracts allow for a new trade off - may it be through separate entities or a fresh start in the same entity - and thus they have an EVA surface that is decreasing in bankruptcy costs. Since bankruptcy costs directly drive costs of the new debt, the equityholder has an incentive to keep the bankruptcy costs as low as possible.

INSERT FIGURE 1.7 ABOUT HERE

1.3.2.4 Convertible bond

The results for a convertible bond are presented in figures 1.8(a) - 1.8(g). What may seem surprising is that - contrary to all the other bonds - under both, a value maximizing and an equity maximizing capital structure, the DVA surface is increasing in bankruptcy costs over most of the grid. The EVA however, is decreasing in bankruptcy costs over most of the grid. The latter was observed before, but not the former. The explanation for that is the hybrid structure of the convertible bond.

INSERT FIGURE 1.8 ABOUT HERE

For the bondholder, the question is what part of the bond dominates. When bankruptcy costs are low, then the convertible bond is in the area of debt i.e. it is in a way a *busted convertible bond*[35]. This is because, when bankruptcy is not very costly, the acquisition is mainly financed with debt and then the conversion bound X_{CV} - being an increasing function of additional debt - is high and thus the probability of conversion is low. The value of a busted convertible bond is equivalent to an unsecured bond. In figure 1.5(a), DVA is in the region where the convertible bond is positive in the area of debt, but very low. Since the convertible bond is an unsecured bond and junior to potential new straight bond, a busted convertible bond is vulnerable to agency. This is why under an equity maximizing capital structure, the claim is diluted with new straight debt. DVA for that situation in figure 1.8(b) is negative in the region where the convertible bond is in the area of debt. The same holds true for the DAC in figure 1.8(e), which is very negative in the region where the convertible bond is in the area of debt. Since the excess leverage from agency also leads to a welfare loss, the welfare loss in figure 1.8(g) is very pronounced in the region where the convertible bond is busted.

[35] A *busted* convertible bond, is a convertible bond where conversion is very unlikely.

Equivalent to the situation with an unsecured straight bond, under an equity maximizing capital structure the equityholder is enabled to take advantage of debt agency in the region where the convertible bond is in the area of debt. That is reflected in figure 1.8(d) and figure 1.8(f). EVA as well as EAG are high in the region where the convertible bond is in the area of debt.

With increasing bankruptcy costs, the debt part of the convertible bond loses value and the conversion option becomes the dominant part of the convertible bond. The bond is then in the area of equity. In this region the equityholder faces the problem, namely the convertible bond's constant debt overhang problem. The equityholder has an incentive to increase leverage in order to keep his own capital contribution as low as possible.

This is however no longer possible when bankruptcy costs are high because this also means that the costs of new debt are high. On top of that the success of classical debt agency is limited since the equityholder cannot compensate the high costs of debt with agency gains. The equityholder cannot compensate his underinvestment incentive with leverage, but he can also not compensate it with agency gains. As a consequence of that EVA in the region where the convertible bond is in the area of equity in figure 1.8(d) is negative. This implies that in this region, the equity cannot overcome the debt overhang problem and thus the equityholder is better off not doing the acquisition. The conversion option may therefore prevent positive NPV acquisitions with high bankruptcy costs.

The bondholder profits from that rather hypothetical situation. Debt agency loses its power, so DAC in figure 1.8(e) are almost zero in the region where the convertible bond is in the area of equity. The equityholder's (hypothetical) capital injection is mainly consumed by the incumbent bondholders in the region where the convertible bond is in the area of equity as illustrated in figure 1.8(b). Since there is not much room left for excess leverage to serve agency purposes, the welfare loss in figure 1.8(g) is also almost zero in the region where the convertible bond is in the area of equity.

1.3.2.5 A note on the size of the value shifts

Since the questions in the intro do not only aim to make an assessment in terms of the direction of value added and value shifts but also in terms of the order of magnitude, some words about it for the bankruptcy perspective. Except for the convertible bond, EVA for realistic bankruptcy costs are between 2% and 5%. DVA is between -4% and 4%, depending if the overall value or the equity value was the basis of the capital structure trade off. For the convertible bond, which includes an embedded option, this option increases the range of the upsides as well as the range of the downside[36] and the figures run up to $-/+20\%$. Welfare loss is between 1% and 2%.

Looking at the numbers, the level bankruptcy costs has an impact on a relevant level on the size of value shifts during acquisition. There is an impact of remarkable level across all contracts, especially for assets with high bankruptcy costs. So in line with Yagil (1989) - where this was confirmed empirically - bankruptcy costs are in important financial parameter that should be considered when assessing a potential acquisition.

1.3.3 The tax perspective

With the earlier definition of a perspective, the tax perspective is a mesh over a grid of the master parameter average annual asset volatility (σ_2) and the tax rates (τ). But it might be more accurate to call it a *leverage ratio perspective,* since the corporate tax rate has a direct effect on leverage.

1.3.3.1 Unsecured straight bond

The results for an unsecured straight bond are presented in figure 1.9. As mentioned at the beginning, the tax rate has a direct impact on the company's ex ante leverage ratio. On the one hand, the higher the tax rate is, the more room there is for a tax shield and thus the higher is the leverage ratio. But on the other hand, the higher the leverage ratio, the less room there is to play games as there remains little leverage capacity and thus little potential for excess leverage. Under both, a value maximizing capital structure and an equity maximizing capital structure, the bondholder favors a regime with a high tax rate for an acquisition - as presented in figures 1.9(a) and 1.9(b).

INSERT FIGURE 1.9 ABOUT HERE

For the equityholder, the preferred tax regime depends on the risk of the acquisition. If the risk of the new assets is low, then for both, a value maximizing capital structure and an equity maximizing capital structure, the equityholder prefers a regime with a low tax rate as presented in figures 1.9(c) and 1.9(d). Otherwise too much of the leverage capacity has to be reserved for the tax shield. There remains little flexibility either to install a value maximizing capital structure or for agency. Also with a high incumbent leverage ratio, a high tax rate and low risk, the equityholder faces another debt overhang like problem. He has to contribute fairly much to

[36] Through the debt overhang problem.

the acquisition in terms of capital, since a lot of the company's leverage capacity has already been used and there remains little room for additional leverage. The bondholder may then once more profit from that investment, since the collateral base is improved and mostly equity financed.

This is observed in figure 1.9(h) which plots the difference between the pre-acquisition and the post acquisition leverage ratio for a value maximizing capital structure. When the acquisition is one with low risk and the tax rate is high, then there is a lot more room to increase the leverage ratio than there would be if the tax rate would be low. Since the equityholder cannot overcome this debt overhang problem, his EVA - as presented in figure 1.9(c) - is negative in the eastern corner and the acquisition is undesirable. The same problem holds true for an equity maximizing capital structure - presented in figure 1.9(d) - when risk is low and the tax rate is high.

When the risk of the acquired assets are high, the trade off is different. The equityholder's debt overhang problem becomes less important and asset substitution becomes more important. If the incumbent leverage ratio is high as a result of the high tax rate, then the equityholder can dilute the incumbent bondholder's claim by acquiring risky assets - classical asset substitution. That is illustrated in figures 1.9(c) and 1.9(d) in the north corner. This is less efficient when the tax rate is low. Then there is less leverage in place and thus less debt that can be diluted. And potential newly issued debt - which is expensive when the risk is high - has to be issued at fair value. Asset substitution - which is the agency issue here - is also what is driving the EAG in figure 1.9(f) - the surface is leaning towards the north corner.

Under an equity maximizing capital structure, the DVA in figure 1.9(b), the DAC in 1.9(e), the welfare loss in figure 1.9(g) as well as the difference in ex ante and ex post leverage ratio in figures 1.9(h) and 1.9(i) experience a reversion of the slope in the middle, similar to the one observed in the bankruptcy cost perspective in figure 1.5. The equityholder is trading off two effects here, namely benefits from claim dilution against costs of excess debt. When walking up that tax rate axis from zero, then the excess leverage increases - and with that the agency costs and the welfare loss. But then further up the grid, this is reversed. Then excess leverage becomes very costly and is reduced. This is why the peak of excess leverage and thus the bottom of welfare loss is somewhere in the interior.

1.3.3.2 Senior bond, callable bond and CLO

For the senior bond, the DVA and the EVA surfaces are presented in figures 1.10(a) and 1.10(b). This trade off is with respect to acquisitions as one would expect: The bondholder favors a high tax rate, because then there is not much financial flexibility left and not a lot of room for agency. For the equityholder, the situation is exactly reversed. As it is presented in figure 1.10(b), for high tax rates the EVA is negative and thus the acquisition is not desirable for the equityholder. This is because of the debt overhang problem that the seniority clause bears and that is reinforced by a high tax rate.

INSERT FIGURE 1.10 ABOUT HERE

The EVA surface for a refinance callable bond presented in figure 1.11(a) is increasing in the tax rate. This might be surprising. The result is driven by the assumption that assets are traded at their unlevered after tax value. Then the higher the interest rate, the larger is the tax shield that the company can generate by leveraging the asset.

INSERT FIGURE 1.11 ABOUT HERE

The EVA of the CLO is presented in figure 1.11(b). With the CLO, the acquisition is leveraged separately. Similar to the callable bond, the EVA is increasing in the tax rate, since the newly acquired assets are traded at their unlevered after tax value.

1.3.3.3 Convertible bond

The situation with the convertible bond is more complicated, since two payoff profiles are mixed. It was noted earlier, exercising the conversion option bears a loss in tax shield. In Stein (1992) convertible bonds were termed *backdoor equity financing.* The loss in tax shield is in some sense a negative consequences of that. The level of the tax rate influences the likeliness of conversion and thus the region in which the conversion option dominates the convertible bond's value. The loss in tax shield is increasing with the tax rate, conversion is therefore more likely when the tax rate is low. This is why DVA for both approaches to maximize the capital structure in figures 1.12(a) and 1.12(b) is high at the lower end of the tax rate axis. The option part of the bond dominates there.

INSERT FIGURE 1.12 ABOUT HERE

The equityholder is again stuck with the constant debt overhang problem that the conversion option bears. The EVA surface in figure 1.12(c) and 1.12(d) is decreasing towards the lower end of the tax rate axis - the region were conversion is likely - which reflects the equityholders debt overhang problem. It is also illustrated in the special figure 1.12(h) which presents the company's ex post difference in leverage ratio between a value maximizing and an equity maximizing capital structure. The excess leverage in figure 1.12(h) is increasing towards the lower end of the tax rate axis, since the equityholder has an incentive to use debt instead of equity, because there is substantial financial flexibility. This excess leverage is diluting to the incumbent bondholder's claim, but it is not the bond part that is affected - it is not dominating - but the option part of the convertible bond. This is because the excess leverage shrinks the value of the equity and thus lowers the value of the incumbent bondholder's hypothetical equity stake. It is a form of claim dilution. This is why - despite the high excess leverage - DAC in figure 1.12(e) are raising steeply towards the lower end of the tax rate axis, but the welfare loss in figure 1.12(g) is only moderately increasing. The agency gains of the equityholder in that situation on figure 1.12(f) are only moderate, since the equityholder is not trying to generate agency gains but is rather trying to avoid agency losses resulting from the debt overhang problem.

On the other end of the tax rate axis - the higher end - the situation is similar to the unsecured straight bond. In that area the bond part of the convertible bond is dominating its ex ante value - the convertible bond is busted. The equityholder is then again in the position to dilute the incumbent bondholder's claim, by taking on excess leverage and acquiring risky assets. The EVA in figures 1.12(c) and 1.12(d) as well as EAG in figure 1.12(f) are - as a result of asset substitution - higher when the acquired asset's annual volatility is high.

At the high end of the tax rate axis, there is a lot of tax shield to gain for the equityholder, since assets are assumed to be traded at their unlevered after tax value. But also at the high end of the tax rate axis, a lot of the company's leverage capacity is already used to create a tax shield. There is not much room for excess leverage to generate agency gains as illustrated in figure 1.12(h). The agency gains from excess leverage in figure 1.12(f) and the excess leverage itself in figure 1.12(h) are therefore not the highest at the high end of the tax rate axis, but somewhere in the middle, where the convertible bond slides from the area of equity to the area of debt. Or to put that in other words, the agency gains are the highest at the point where the dominating part of the convertible bond is switched from the option part to the bond part.

What is now interesting to see is that - despite the fact that agency through excess leverage is the most efficient in the middle of the grid - generating EVA by taking advantage of the tax shield is creating more value under an equity maximizing capital structure than taking advantage of agency. EVA in figure 1.12(d) is higher at the high end of the tax rate axis than in the middle, where agency is the most efficient. So, if a convertible bond is the incumbent bond, a high tax rate tends to bust the incumbent convertible bond in the event of an acquisition. But it also offers some protection to the incumbent bondholder against agency, since under a high tax rate agency through excess leverage becomes unattractive.

1.3.3.4 A note on the size of the value shifts

The size of the influence of a change in tax rate to the value shifts is in the range of 8% for bonds without options and up to 30% for realistic figures for a convertible bond. The reason for that difference is the potential destructive effect of conversion options on the tax shield. This seems high compared with Graham (2000), who estimated the tax benefit of debt to be between 4% and 10%. The model in this paper clearly overestimates the tax benefits to debt. This is because the model is a static model of capital structure which tend to overestimate leverage ratios and thus tax benefits of leverage. A dynamics model like Goldstein et al. (2001) would allow for more decent leverage ratios, but would also tremendously increase the complexity of analyzing structured debt contracts and acquisitions.

Are tax benefits/losses of acquisitions therefore of negligible size? Academic and anecdotal evidence suggests that the answer is no. Lewellen (1971) first suggested tax benefits as a reason for an acquisition. Brealey et al. (1981) however, list tax benefit from acquisitions under *dubious reasons for mergers.* But it seems that their categorization in *sensible* and *dubious* reasons for mergers would be largely equivalent to a categorization into *economic* and *financial* reasons for mergers. So Brealey et al. (1981) generally have doubts that there are financial reasons for an acquisition. The results in Leland (2007) as well as the results in this paper suggest that there are financial reasons for an acquisition.

Tax issues are an important part of every due diligence prior to an acquisitions. This is to some extend because of fiscal positions that occur as a result of the implementation of the merger e.g. legal restructuring or deferred taxes that must be realized.

1.4 What is a good contract...

This chapter aims at transferring the above analysis in recommendations for companies where unexpected acquisitions are potentially an issue. It is therefore set to answer 6 that was posed at the beginning.

1.4.1 ...when risk is the main concern?

A simple unsecured straight bond is not a good choice. It is vulnerable to agency - especially when the risk is high. Although one would expect companies to avoid to generate agency gains - they want to keep a *clean* credit history - it is in an actual case difficult to determined if the gains that the shareholder make from the acquisition are a result of value added or of agency. If both, the debt certificates and the shares are listed, the price movements and the movements in volatility may give a hint of what happens, but it is still difficult to tell. But even in the absence of agency, the equityholder favors risky acquisitions as a result of the convexity of his claim. The straight bond however is a concave claim and favors save acquisitions.

It has been discussed in the last section, how the situation changes when one of the following contractual features is added to the debt contract: A seniority clause, an early redemption clause, bankruptcy remoteness and an embedded conversion option. Unless the acquisition is negative i.e. it is a spin-off, a seniority clause offers almost perfect protection against debt dilution and asset substitution. It creates however a new agency problem that is similar to debt overhang. It is especially strong when the risk of the acquisition is somewhat similar to the assets in place. Then most of the added value of the acquisition is absorbed by the bondholders and the acquisition loses attractiveness for the equityholder.

An embedded call option offers a solution to this problem. It allows the equityholder to redeem the incumbent bond and refinance it with a bond issued at fair value. Within the scope of this model, an early redemption clause solves the debt overhang problem associated with the seniority clause. A similar argument is made in Childs et al. (2005), but with short term debt rather than with callable debt. Callable bond often include a penalty fee, so this option to restructure is - as opposed to the model in this paper - costly. But as recognized in Hennessy and Tserlukevich (2008), this penalty fee is tax deductible like interest, which lowers the cost of the option to restructure.

Securitization is a different solution to the two agency problems mentioned above. Leland (2007) argues that there are large benefits from securitization when the company backs the CLO with assets that are very save ($\sigma_2 = 0.04$) or that are very risky ($\sigma_2 = 0.5$). Figure 1.3(c) presents the difference in EVA between securitization and restructuring an incumbent callable bond. I use numbers a bit different, but I confirm that securitization is valuable for high risk assets. On the other end of the scale there is no advantage of securitizing a low risk acquisition but I do not go as deep down the scale as in Leland (2007).[37]

[37] The median annual asset volatility of a AAA-rated company is estimated at 0.21 by Schaefer and Strebulaev (2008). Although the value in Schaefer and Strebulaev (2008) might be overestimated, it is to doubt if there

A convertible bond is rather messy when it comes to an acquisition. It is vulnerable to agency and the conversion option creates a debt overhang problem for risky acquisitions. Anecdotal evidence presented earlier shows, that convertible bonds are frequently refinanced around acquisitions, sometimes the bondholders even have some of the bargaining power. Taking evidence from this model, it makes sense to issue convertible bonds callable to avoid the potential problems around an acquisition. In Vanden (2009) an altered payoff structure for a convertible bond is proposed that - within his framework - solves the agency problems associated with a convertible bond around an acquisition. However, I think there is a legal and an economic problem associated with that payoff structure: I doubt whether an instrument with the payoff structure in Vanden (2009) would be classified as debt by the tax authority or the bankruptcy court, more likely it will be classified as hidden equity. Furthermore, the payoff structure is such that default occurs when asset values are high. This leads to high ex post bankruptcy costs and thus increases the cost of debt.

The overall recommendation from the evidence of the model in this paper would be to issue the incumbent debt callable and with a seniority clause. If the acquisition is very risky, then securitizing the acquisition makes sense. A convertible bond ought to be issued callable, to avoid potential problems around an acquisition.

1.4.2 ...when bankruptcy costs are the main concern?

The issues for an unsecured straight bond are similar to the risk perspective but different in order of magnitude. Agency issues are the most pronounced somewhere in the middle of the grid at an average level and they are low for very high and very low bankruptcy costs. A regime with low bankruptcy costs is favorable for the equityholder. For this regime, there are almost no agency costs for the incumbent bondholder. For high bankruptcy costs agency is reduced, but does not entirely disappear.

A seniority clause reverses the equityholder's trade off: As a result of the debt overhang problem associated with that clause, the equityholder favors now a regime with high bankruptcy costs. This makes it problematic.

A call option preserves the shape of the EVA, the equityholder favors a regime with low bankruptcy costs. For securitization - the call option's rival - Gorton and Souleles (2007) put forward, that bankruptcy cost consideration are the most important motive for asset securitization and that companies with risky assets and high bankruptcy costs are likely to securitize

exist corporate assets that are as deep down the lower end of the volatility scale as in Leland (2007). In 2007, residential mortgage were thought to be at that low level - today the assessment would probably be different.

assets. Figure 1.7(c) presents the difference in EVA between securitization and restructuring an incumbent callable bond. As opposed to Gorton and Souleles (2007) and similar to Leland (2007), this difference is low over the entire grid. The difference is the largest 1.5% when the assets have low bankruptcy costs and high risk.

If a convertible bond is the incumbent bond, then the situation is - from an agency perspective - ambivalent: On the one hand, the bankruptcy costs influence the likelihood of actual conversion of a convertible bond. Everything being equal, the higher the bankruptcy costs, the more is the conversion option worth relative to the bond part of the convertible bond - the convertible bond is in the area of equity. So, when bankruptcy costs are high, the equityholder's debt overhang problem is more sever and he has no incentive to pursue acquisitions. On the other hand, when bankruptcy costs are low, the bond part dominates the situation - the convertible bond is in the area of debt. The convertible bond is junior to any new debt and thus very vulnerable to agency. The bottom line for the convertible bond is, that it is vulnerable to agency around acquisitions and the level of bankruptcy costs determine which stakeholder suffers from the agency costs. Again a convertible bond should be issued callable.

The overall recommendation for a regime with low bankruptcy costs is unsecured straight debt or securitization. The first recommendation is because claim dilution through acquisitions is nearly impossible when bankruptcy costs are low. Also under unsecured straight debt, the equityholder actually favors a regime with low bankruptcy costs. This holds across the entire risk grid.

For assets with high risk, securitization is favorable. It makes the equityholder better off than callable debt, there is no claim dilution and no debt overhang and the seniority clause is potentially harmful for the bondholder. So it is certainly true for the specific case in Leland (2007) that bankruptcy costs consideration are not relevant in size. A more extensive analysis however, reveals that - in line with Gorton and Souleles (2007) - bankruptcy cost indeed drive the application of securitization. In a way both papers are right, Leland (2007) for the specific case analyzed in section IV.B while Gorton and Souleles (2007) is right in terms of quality and for a broader consideration.

1.4.3 ...when taxes are the main concern?

Taxes help to protect the holder of an unsecured straight bond from agency. This is because with high taxes, much of the leverage capacity of the company has to be used for a tax shield and there remains little flexibility for excess leverage for agency.

For the same reason, high taxes worsen the debt overhang problem that the equityholder faces with a seniority clause.

Both, callable debt and securitization favor a high tax rate, since it increases the tax shield generate with the acquisition. In figure 1.7(c), the difference between the EVA after an acquisition involving a redeemed callable bond and one involving securitization. The tradeoff between callable debt and securitization depends more on risk than it does in the tax rate. Generally, a higher tax rate tends to favor callable debt.

The convertible bond is again vulnerable to agency through claim dilution and debt overhang. It ought to be issued callable.

When the tax rate is low, unsecured debt is vulnerable to agency. The debt overhang associated to a seniority clause is low and thus a call clause is almost neutral. A callable senior bond is therefore to favor when taxes are low.

When taxes are high, claim dilution is less of a problem but an unsecure straight bond is still vulnerable to asset substitution. If the risk of the acquisition is not too high, unsecured straight debt can be appropriate. If it is not, again callable senior debt is to favor.

1.5 Conclusion

This paper contributes to the literature of capital structure by analyzing the impact of an unexpected corporate acquisition on a set of different incumbent structured debt contracts. Unsecured debt, senior debt, callable debt, securitization and conversion options were analysed in this paper.

Unsecured debt is vulnerable to claim dilution and asset substitution. By taking on excess leverage the equityholder can transfer value from the unsecured straight bond to his own claim. High risk favors agency costs, while high bankruptcy costs - through high costs of leverage - and a high tax rate - through the fact that most of the company's debt capacity has to be allocated to the tax shield - offer some protection from debt agency. But especially the second protection immediately opens another agency problem, namely one that is similar to debt overhang. The bondholder is potentially free riding on acquisitions that the equityholder is financing.

A seniority clause protects the bondholder from debt agency. But it allows the bondholder again to free ride on the acquisition. With an incumbent bond that has a seniority clause, the equityholder leaves value added on the table that is absorbed by the bondholder. This problem is especially pronounced when risk and bankruptcy costs are low.

A new motive was proposed to issue callable bonds. An early redemption clause offers the equityholder the option to restructure the incumbent debt. The equityholder can refinance a bond that would otherwise forces him to leave money on the table. A seniority clause combined with a call option is often a good choice for a company where unexpected acquisition might be an issue. The seniority clause protects the bondholders from agency and the call option makes sure that there will be no money left on the table.

Securitization is a structuring tool that applies bankruptcy remoteness. This offers protection from agency as well against both, claim dilution and debt overhang. It also helps to reduce the financing costs of very high risk acquisition by separating the bankruptcy risk and taking advantage of limited liability.

Incumbent convertible bonds are problematic with acquisitions. When the bond is in the area of debt it is vulnerable to claim dilution, when it is in the area of equity, the equityholder suffers a constant debt overhang problem. It makes sense to issue convertible bonds callable and anecdotal evidence suggest that convertible bonds are refinanced around acquisitions.

In terms of order of magnitude, the value added and the value transfers between the claimholders are of perceivable size, but mostly within single digit percentages. Anecdotal as well as academic evidences suggest that this is a level that is relevant to the investors implying that careful structuring of debt contracts has not only implications in quality but also in quantity. The welfare loss from agency is similar to Mauer and Sarkar (2005): not very pronounced and seldom about 1%. It is associated with excess leverage to dilute debt claims.

Finally the question to answer was what a good contract is for companies with potential acquisitions. A callable senior bond offers protection to both forms of the agency problem by adding protection to the bondholder and flexibility to the equityholder. For high risk acquisition it can be worth while to explore the advantages of bankruptcy remoteness. If risk is low then there is no need for structuring and simple unsecured straight debt is applicable. Convertible bonds are problematic around acquisitions and should be redeemed.

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Appendix

I Standard parameter values

Fixed Parameters		
Description	Parameter	Value
Expected present value of asset 1	X_1^0	100
Expected present value of asset 2	X_2^0	100
Annual volatility of asset 1	σ_1	0.22
Conversion ratio of a convertible bond	λ	0.25

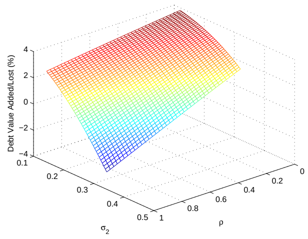
Table 1.1: Values for parameters of the model in section 1.2 that are fixed.

Fixed Parameters, unless they are part of the examples		
Description	Parameter	Value
Correlation between asset 1 and asset 2	$\rho_{1,2}$	0.5
Bankruptcy costs	α	0.23
Corporate tax rate	τ	0.2
Time to maturity	T	5 years

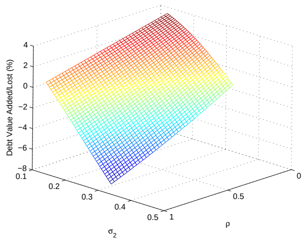
Table 1.2: Values for parameters of the model in section 1.2 that are fixed unless mentioned otherwise.

II Illustrations on the risk perspective

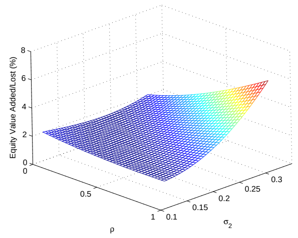
i Unsecured straight bond



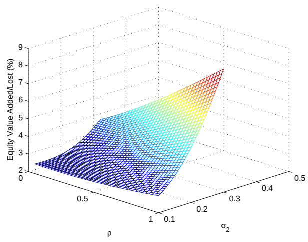
(a) Debt value added, value maximizing capital structure



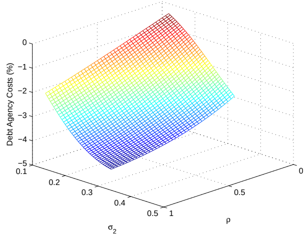
(b) Debt value added, equity maximizing capital structure



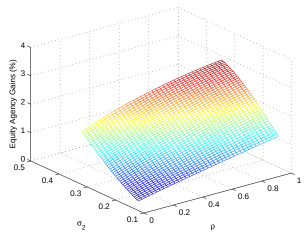
(c) Equity value added, value maximizing capital structure



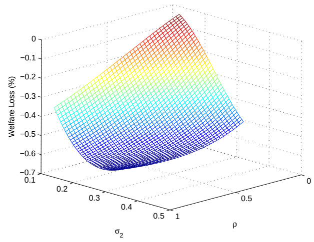
(d) Equity value added, equity maximizing capital structure



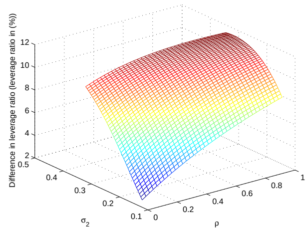
(e) Debt agency costs



(f) Equity agency gains



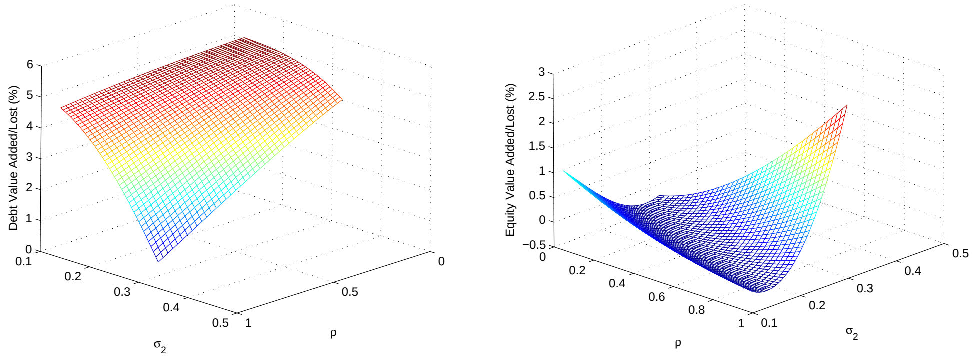
(g) Welfare loss



(h) Excess leverage of an equity maximizing capital structure

Figure 1.1: The value added/loss for the stakeholder, the agency gains/losses, the welfare loss and the excess leverage of an agency maximizing capital structure of an acquisition for an *unsecured straight bond* over a σ_2/ρ-plane.

ii Senior secured bond

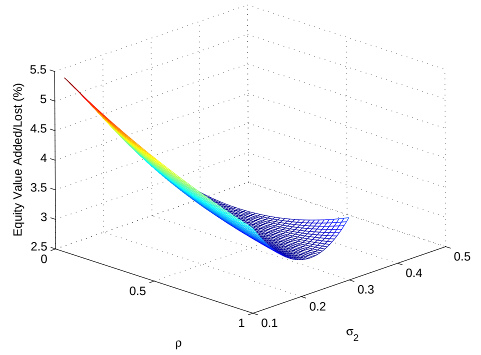


(a) Debt value added

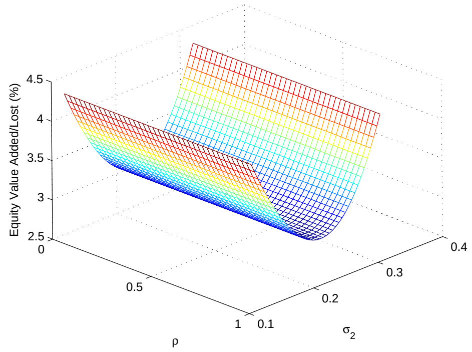
(b) Equity value added

Figure 1.2: The value added/loss for the stakeholder of an acquisition for a *senior secured bond* over a σ_2/ρ-plane. The value maximizing and the equity maximizing capital coincide in this case.

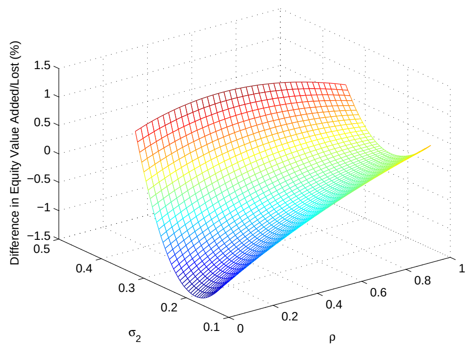
iii Callable bond and CLO



(a) Equity value added, callable bond that has been refinanced



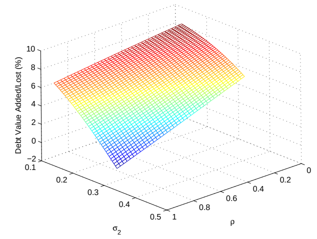
(b) Equity value added, CLO



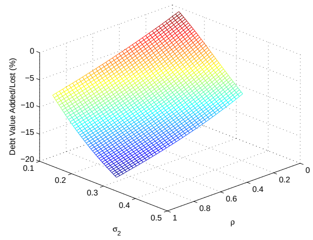
(c) Difference in Equity value added between a CLO and a refinanced callable bond

Figure 1.3: The equity value added/loss of an acquisition for a *callable bond* that has been refinanced and a *CLO* over a σ_2/ρ-plane. The value maximizing and the equity maximizing capital coincide in this case.

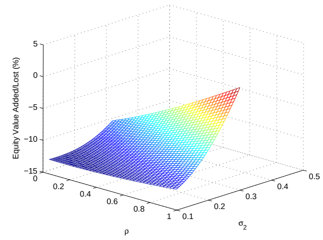
iv Convertible Bond



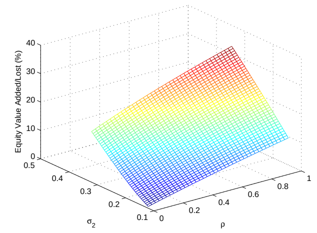
(a) Debt value added, value maximizing capital structure



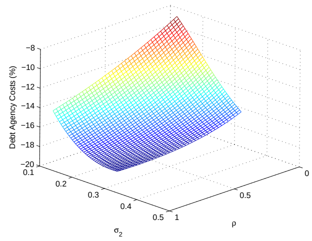
(b) Debt value added, equity maximizing capital structure



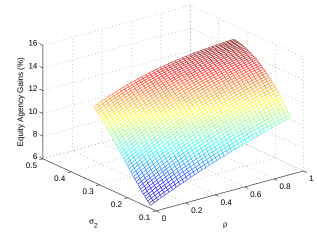
(c) Equity value added, value maximizing capital structure



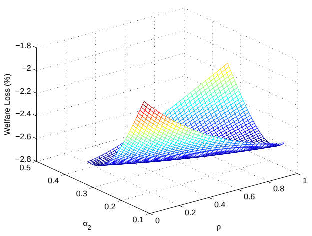
(d) Equity value added, equity maximizing capital structure



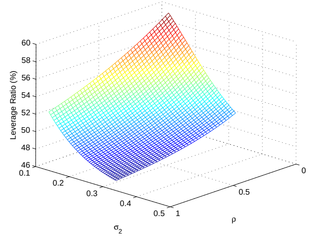
(e) Debt agency costs



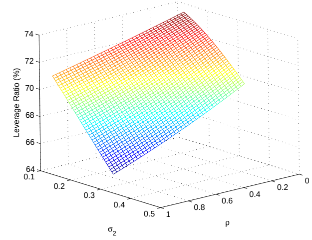
(f) Equity agency gains



(g) Welfare loss



(h) Post acquisition leverage ratio, value maximizing capital structure

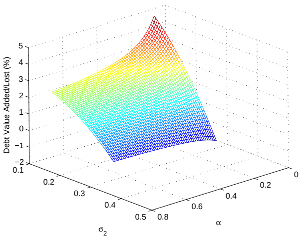


(i) Post acquisition leverage ratio, equity maximizing capital structure

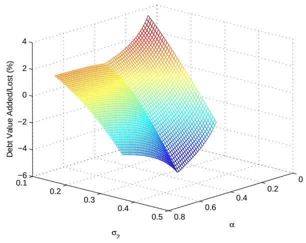
Figure 1.4: The value added/loss, the agency gains/losses, the welfare loss and the post acquisition leverage ratios of an acquisition for a *convertible bond* over a σ_2/ρ-plane.

III Illustrations on the bankruptcy costs perspective

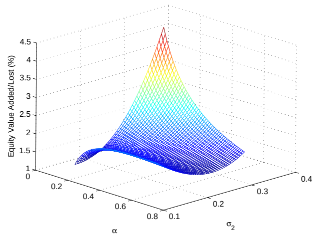
i Unsecured straight bond



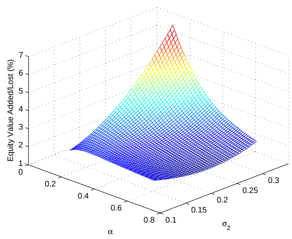
(a) Debt value added, value maximizing capital structure



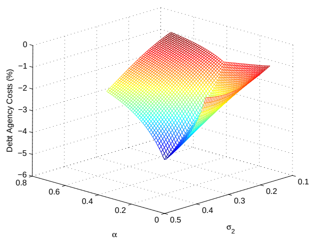
(b) Debt value added, equity maximizing capital structure



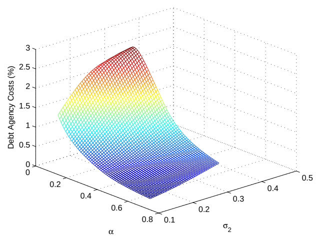
(c) Equity value added, value maximizing capital structure



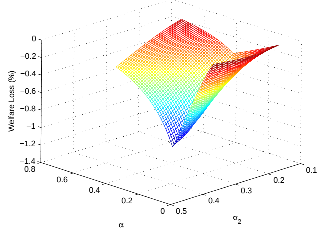
(d) Equity value added, equity maximizing capital structure



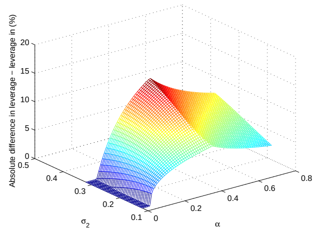
(e) Debt agency costs



(f) Equity agency gains



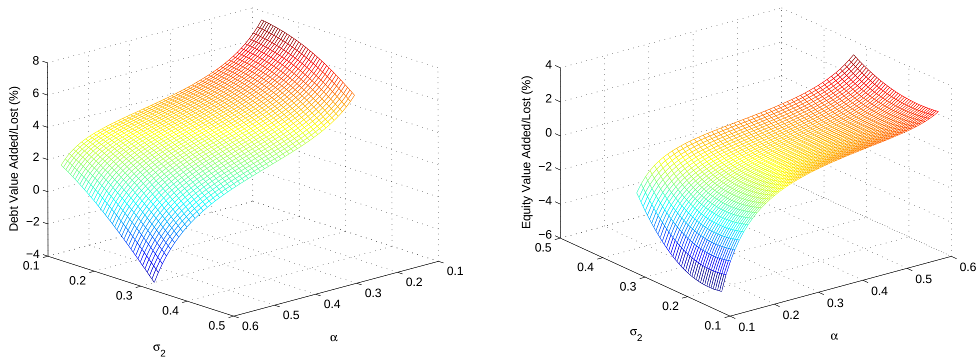
(g) Welfare loss



(h) Excess leverage of an equity maximizing capital structure

Figure 1.5: The value added/loss for the stakeholder, the agency gains/losses, the welfare loss and the excess leverage of an agency maximizing capital structure of an acquisition for an *unsecured straight bond* over a α/σ_2-plane.

ii Senior secured bond

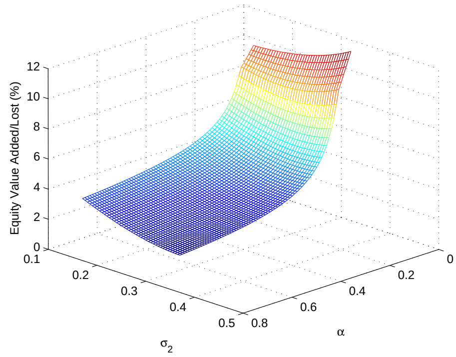


(a) Debt value added

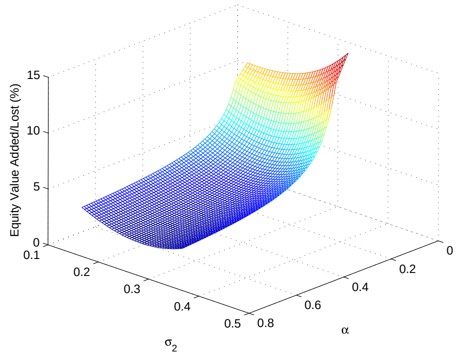
(b) Equity value added

Figure 1.6: The value added/loss for the stakeholder of an acquisition for a *senior secured bond* over a α/σ_2-plane. The value maximizing and the equity maximizing capital coincide in this case.

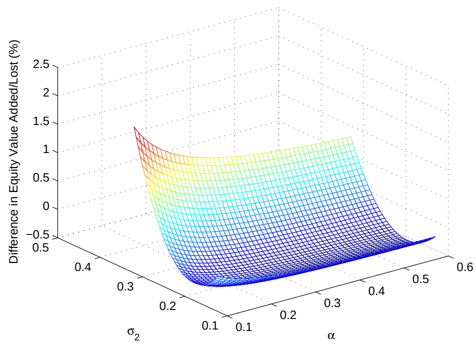
iii Callable bond and CLO



(a) Equity value added, callable bond that has been refinanced



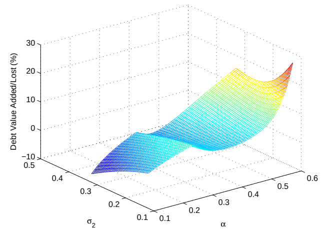
(b) Equity value added, CLO



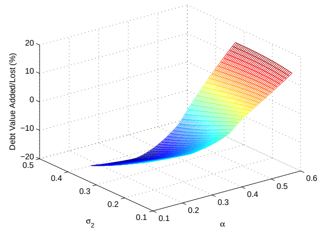
(c) Difference in Equity value added between a CLO and a refinanced callable bond

Figure 1.7: The equity value added/loss of an acquisition for a *callable bond* that has been refinanced and a *CLO* over a α/σ_2-plane. The value maximizing and the equity maximizing capital coincide in this case.

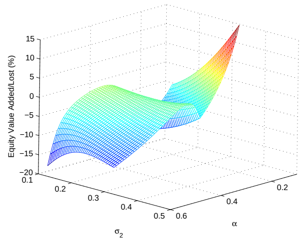
iv Convertible Bond



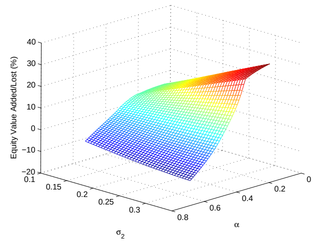
(a) Debt value added, value maximizing capital structure



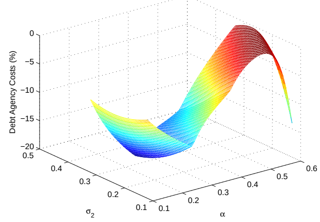
(b) Debt value added, equity maximizing capital structure



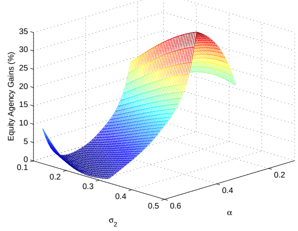
(c) Equity value added, value maximizing capital structure



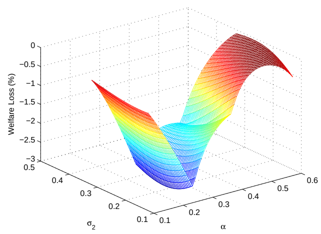
(d) Equity value added, equity maximizing capital structure



(e) Debt agency costs



(f) Equity agency gains

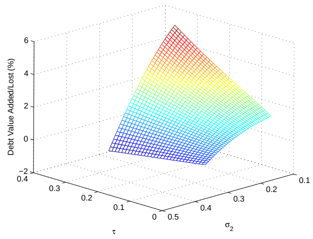


(g) Welfare loss

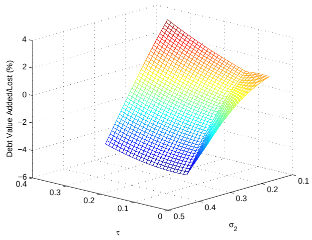
Figure 1.8: The value added/loss, the agency gains/losses and the welfare loss of an acquisition for a *convertible bond* over a α/σ_2-plane.

IV Illustrations on the tax Perspective

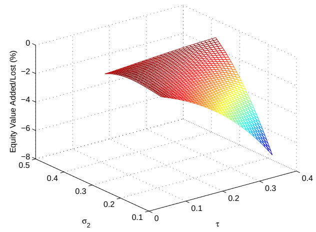
i Unsecured straight bond



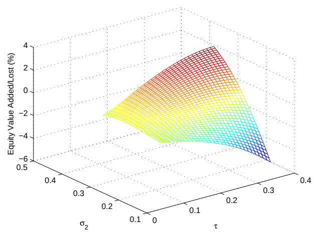
(a) Debt value added, value maximizing capital structure



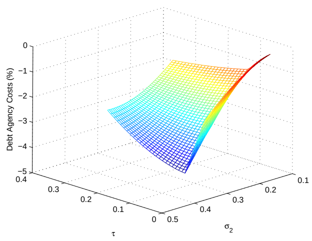
(b) Debt value added, equity maximizing capital structure



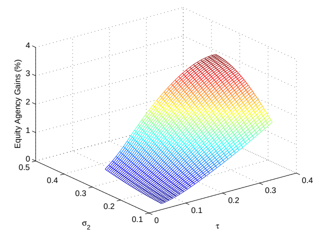
(c) Equity value added, value maximizing capital structure



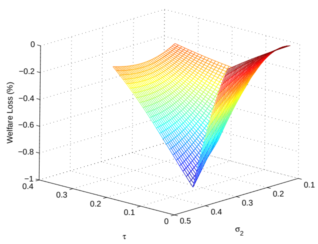
(d) Equity value added, equity maximizing capital structure



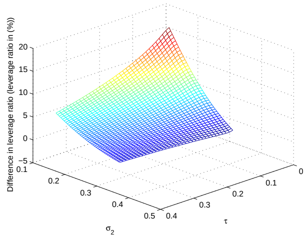
(e) Debt agency costs



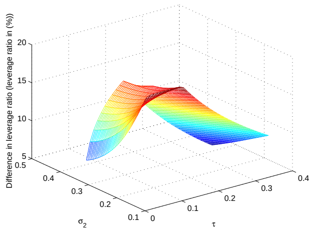
(f) Equity agency gains



(g) Welfare loss



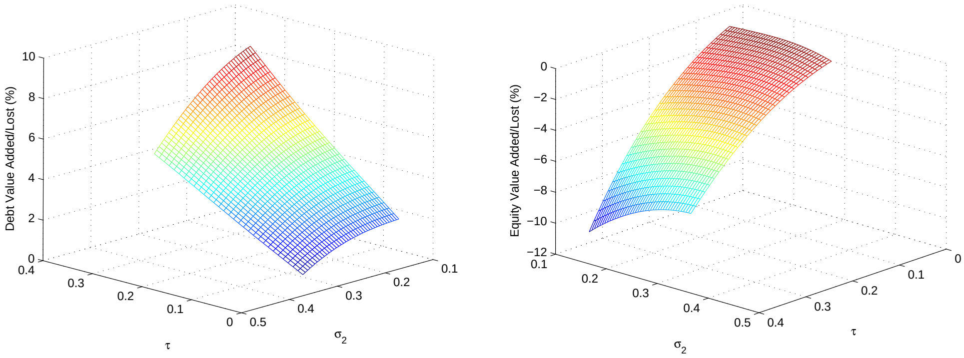
(h) Difference in leverage ratio before and after the acquisition, value maximizing capital structure



(i) Difference in leverage ratio before and after the acquisition, equity maximizing capital structure

Figure 1.9: The value added/loss for the stakeholder, the agency gains/losses, the welfare loss and the difference in leverage of an acquisition for an *unsecured straight bond* over a τ/σ_2-plane.

ii Senior secured bond

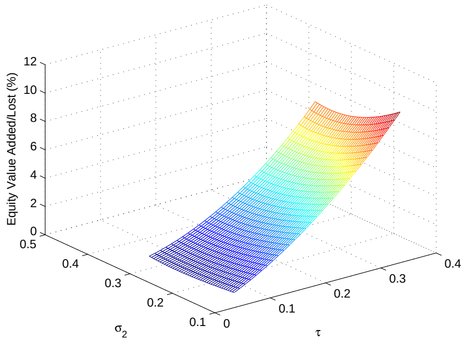


(a) Debt value added

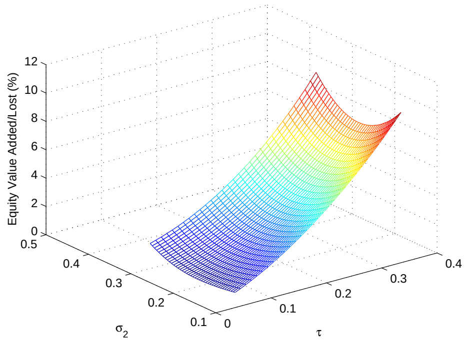
(b) Equity value added

Figure 1.10: The value added/loss for the stakeholder of an acquisition for a *senior secured bond* over a τ/σ_2-plane. The value maximizing and the equity maximizing capital coincide in this case.

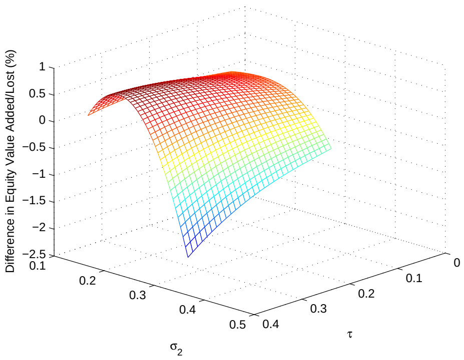
iii Callable bond and CLO



(a) Equity value added, callable bond that has been refinanced



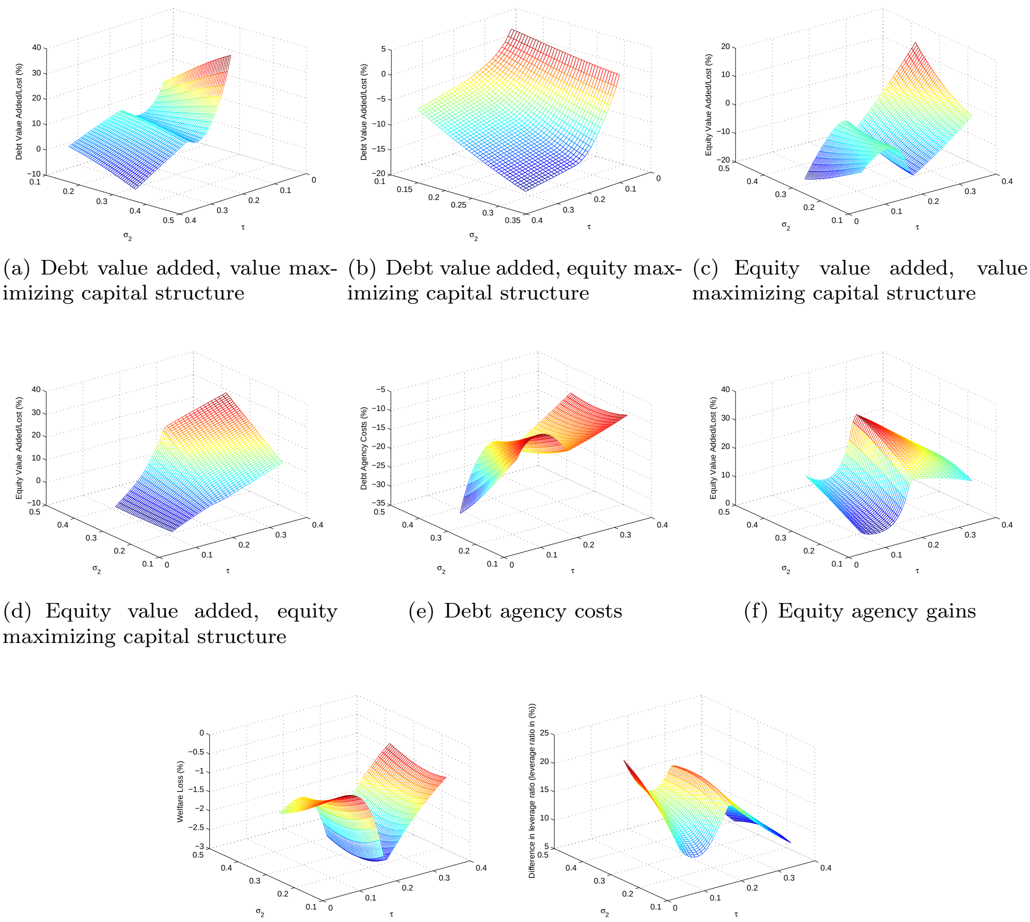
(b) Equity value added, CLO



(c) Difference in Equity value added between a CLO and a refinanced callable bond

Figure 1.11: The equity value added/loss of an acquisition for a *callable bond* that has been refinanced and a *CLO* over a τ/σ_2-plane. The value maximizing and the equity maximizing capital coincide in this case.

iv Convertible Bond



(a) Debt value added, value maximizing capital structure

(b) Debt value added, equity maximizing capital structure

(c) Equity value added, value maximizing capital structure

(d) Equity value added, equity maximizing capital structure

(e) Debt agency costs

(f) Equity agency gains

(g) Welfare loss

(h) Excess leverage of an equity maximizing capital structure

Figure 1.12: The value added/loss for the stakeholder, the agency gains/losses, the welfare loss and the excess leverage of an agency maximizing capital structure of an acquisition for an *convertible bond* over a τ/σ_2-plane.

Chapter 2

Market segmentation and capital structure

Gabriel H. Neukomm[1]

Abstract

Most contributions on capital structure assume a frictionless market, in which the optimal capital structure depends solely on a company's characteristics. Recent empirical evidence on market segmentation in the corporate bond market has called this assumption into question. This paper analyzes the implications of segmentation in the corporate bond market on optimal capital structure. The paper provides a number of insights, three of which are as follows: First, under market segmentation the capital structure trade off exhibits discontinuities and the optimal solution is potentially a corner solution. Second, around the segmentation bounds companies have a local incentive to constrain leverage in order to maintain their position in the higher rated market segment. This leads to apparently underleveraged companies. Third, the degree of arbitrage activity in a weakly segmented market influences the optimal capital structure and potentially mitigates some of the costs of market segmentation to companies, if the activity has enough intensity.

JEL Classification Numbers: G24, G32

Keywords: Capital structure, market segmentation, corporate finance with frictions

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2.1 Introduction

After the publication of the seminal paper of Modigliani and Miller (1958), a large number of subsequent publications have analyzed the effects of a comprehensive set of issues[2] on a company's capital structure decision. Also a number of frameworks[3] for the optimal capital structure have been proposed.

Especially influential were Merton (1974), Leland (1994) and Leland and Toft (1996), which started a stream of literature that relies on contingent claim valuation. These papers however, assume an entirely frictionless capital market with complete market access of all market participants. In this type of framework, debt claims are redundant assets. This enables arbitrage free valuation which is entirely independent of the market's characteristics and solely depends on the company's characteristics. It becomes irrelevant to the capital structure decision in what market segment a company operates i.e. what investors invest into a company's securities. This assumption is inherent to a wide range of models and contributions to capital structure.

It is widely accepted that this assumption conflicts with the extensive anecdotal and empirical evidence on frictions in the corporate bond market. Modigliani and Sutch (1966) as well as Modigliani and Sutch (1967) first documented a form of maturity-induced market segmentation in the market for government bonds. Kisgen (2006), Kisgen and Strahan (2010), Chen et al. (2010) and Chernenko and Sunderam (2012) among others documented, how the demand for and the costs of corporate debt capital are influenced by market segmentation.

This is reinforced by anecdotal evidence. The market access of an individual investor often depends on his profile.[4] There is a substantial hedge fund activity devoted to arbitrage market segmentation[5] and the survey conducted by Graham and Harvey (2001) on the practice of corporate finance identified *ratings* as a very important decision variable. This implies that capital structure is driven by factors that lie beyond a company's fundamentals.

This paper addresses the implications of market segmentation on capital structure. In a two period model of capital structure that has its root in Leland (2007), combined with a mean-variance market for corporate securities that is segmented, this paper aims to answer how com-

[2]These issues include *taxes* such as in Miller (1977), *bankruptcy costs* such as in Hirshleifer (1966) and various forms of *agency* like claim dilution in Schwartz (1989), *debt overhang* in Myers (1977) and the *free cash flow problem* in Jensen (1986).

[3]These include the *trade-off theory* first formalized by Kraus and Litzenberger (1973), the *pecking order theory* proposed in Myers and Majluf (1984) and the *market timing theory* proposed in Baker and Wurgler (2002).

[4]This includes aspects such as private vs. institutional investor, various definitions of *qualified* and *unqualified* investors and protection to investors in funds among others.

[5]This takes place under the label *capital structure arbitrage.* See Berndt and Veras de Melo (2003) for an introduction to capital structure arbitrage and Choi et al. (2010) for the empirical importance of arbitrage capital to the non-investment grade segment of the corporate bond market.

panies are affected by and how their capital structure trade off is altered by strong and weak market segmentation, as well as how companies incorporate the effects of market segmentation into their choice of capital structure.

In the model, there is a company that has assets in place and implements its capital structure. If the company dips into the bond market, it is exposed to market segmentation in the corporate bond market. Market segmentation means, that not all investors have the same opportunity set, the market is split into subsets. Under *complete market segmentation,* which is what is assumed in section 2.3, all investors are subject to market segmentation and have access only to one market segment. The subsets do not communicate with each other. In section 2.4, the market is assumed to be *weakly segmented,* which means that some investors have access to all market segments while other investors remain restricted to invest in one single market segment.

The friction of complete market segmentation that is assumed in section 2.3 activates the relevancy of the supply characteristics in the corporate bond market to the valuation of a bond. A company's objective function to optimal capital structure is a trade off in the spirit of Kraus and Litzenberger (1973). The company receives the advantage of the tax shield but it carries the burden of bankruptcy costs and - as a contribution of this paper - it carries the burden of market segmentation associated with its securities. The burden of market segmentation associated with a particular security, consists of the discount of the security's equilibrium price to that security's value in a frictionless market. A security's value in a frictionless market in turn corresponds to the arbitrage free value in the literature on capital structure in frictionless markets.

Under complete market segmentation, this discount depends on three elements: First it depends on the question in what market segment the company is active. The assignation to a market segment is drawn according to a company's risk level, which includes both, the risk associated with the company's assets as well as the risk associated with the company's leverage. Second, the market segments differ in the supply of capital, which is in this model assumed to be finite and declining with lower market segments. The discount thus depends on the aggregate supply of capital of the mean-variance market of the segment the company is active in. Third, the discount also directly depends on the company's risk level. So, what ultimately drives the discount is the supply of capital in the market segment the company is active in and the risk level associated with a corporate security. Under weak market segmentation in section 2.4, the discount additionally depends on the degree of arbitrage activity. This extends the standard trade off model to a generalized trade off model that accounts for the characteristics of a segmented corporate bond market. This generalization has a direct effect on companies' capital structure and leads to rationales for some observations on corporate financing behavior, that cannot be explained under the standard trade off model.

The transition from one segment to another causes a discontinuous shock to the supply of capital a company enjoys i.e. this risk-induced market segmentation leads to discontinuities in a company's capital structure trade off. These discontinuities occur if a company operates at the boundary of a market segment, and allow that for some companies - but not necessarily all - the optimal capital structure is a corner solution.

This is a stylized fact that has been recently document in the empirical literature on capital structure, such as in Kisgen (2006), Kisgen and Strahan (2010), Chen et al. (2010) and Chernenko and Sunderam (2012). Kisgen (2006) as well as Kisgen and Strahan (2010) investigate the influence of discrete i.e. discontinuous costs associated with a change in credit rating on capital structure. Chen et al. (2010) provide evidence for a discontinuous shock between the investment grade and the non-investment grade segment by comparing cumulative abnormal returns subsequent to a mechanical change in credit ratings. Chernenko and Sunderam (2012) use a regression discontinuity approach and find a discontinuity between the investment grade and the non-investment grade market segment. The generalized trade off model in this paper provides a theoretical foundation and explanations that match these stylized facts based on risk-induced market segmentation in the corporate bond market.

As a result of these discontinuities, some companies - but not all - have an incentive to maintain their assignment to a higher market segment. As the risk of a corporate bond - which is the decisive parameter for the segment assignment - is influenced by the choice of leverage, such a company is able to implement its assignment to the higher segment by a reduction in leverage. This creates a new rationale for the *underleverage puzzle* that was observed by Miller (1977) and Graham (2000). Market segmentation creates a local incentive to constrain leverage in order to remain in a higher market segment. This materializes itself in apparently underleveraged companies and additionally explains the dispersion in the data on leverage ratios.

In an insightful contribution, Choi et al. (2010) have analyzed the role of arbitrage activity to the supply of corporate bonds.[6] They simultaneously investigated demand and supply of corporate bonds and they found, that various measures for the flow of arbitrage capital have a significant influence on the demand for corporate capital. This holds especially true for the 2008 short selling ban, that precluded some arbitrage strategies on corporate bonds.

Section 2.4 provides a theoretical foundation that matches this empirical fact. In the respec-

[6] Although there study focuses on convertible bonds, there is also a substantial degree of straight debt included in their sample.

tive section, the assumption of complete market segmentation is progressively weakened towards a form of weak market segmentation. Under weak market segmentation there are certain investors - termed *arbitrage traders* - that have full market access. To these investors the corporate bond is approximately a redundant asset and as a consequence, their valuation of a bond corresponds to the value in a frictionless capital market. This creates an arbitrage opportunity for these traders between their own assessment of the bond's value and the equilibrium price of the bond, that is induced by the mean-variance capital supply of the investors, that remain subject to market segmentation. With growing arbitrage activity, the market converges to a frictionless market and the segmentation induced friction declines. Consistent with economic intuition the costs and influence of market segmentation declines with the market's convergence to a frictionless market. If the arbitrage activity is high enough, the costs of market segmentation eventually decline enough, such that the company's local incentive to underleverage disappears. If the arbitrage traders account for the entire volume of the bond in question, the market is fully arbitraged and the arbitrage traders' arbitrage free valuation prevails.

The paper finally discusses and recognizes the role of the initial and sustained ownership structure of a company's corporate bonds with respect to an owner's market access. As the degree of arbitrage activity influences the supply and the valuation of corporate bonds, this has consequences on a company's costs of debt and on a company's assignment to a market segment. But the flow of arbitrage capital varies empirically over time. A shift in the volume of arbitrage activity can therefore have consequences for a company's capital structure without an actual change in the company's fundamentals.

There are a few older and some very recent contributions that address the consequences of market segmentation and market characteristics to capital structure. Similar to this paper, Rubinstein (1973b) and Glenn (1976) address the issue in a mean-variance framework. Rubinstein (1973b) considers overlapping markets with different *tastes* i.e. levels of capital supply. He shows how an interior solution to the optimal capital structure prevails, but the respective paper is primarily interested in a social perspective and not in the perspective of an individual company's optimal capital structure. Glenn (1976) considers the issue of optimal capital in a segmented capital market. But the respective paper does not explicitly model how market segmentation materializes and the conclusions remain very general.

The very recent contributions of Morellec (2010) and Hugonnier et al. (2011) take a different approach. Their interest lies in the consequences of uncertainty on the actual flow of additional capital in the future, rather than in market segmentation. Their modelling approach explains a substantial range of puzzling observations in the practice of corporate finance. It especially creates an explanation for substantial corporate cash holdings. According to the view presented here, the assumption of uncertain future capital supply in Morellec (2010) and Hugonnier et al. (2011) and the assumption of market segmentation are complements rather than substitutes and could eventually be combined.

The framework for capital structure in this paper is a firm based model. It is widely accepted[7], that this type of firm based model - static or dynamic - does not do very well in explaining observed credit spreads. For that purpose various extensions have been proposed such as additional risk factors as in Demchuk and Gibson (2006) or additional risk factors combined with endogenous investments such as in Arnold et al. (2012). The present paper solely adds a friction to a company's financing problem and not an additional risk factor. It additionally assumes that a private owner manager provides sufficient equity capital to the company.[8] As a consequence this paper does not make a contribution to the literature on the *credit spread puzzle.*

The remainder of the paper is organized as follows: Section 2.2 gives a motivation based on theoretical, anecdotal and empirical evidence on why market segmentation plays an important role in corporate finance. Section 2.3 presents a generalized trade off model of optimal capital structure that incorporates strong market segmentation. Section 2.4 generalizes this model futher towards weak market segmentation and discusses the implications. Section 2.5 concludes.

2.2 Why market segmentation matters: anecdotal and empirical evidence

2.2.1 Traditional models on capital structure and market segmentation

A fruit of the assumption of a frictionless capital market is the *irrelevance of the investor.* What is meant with that term is, that the demand for risky assets of the external investors is irrelevant to the pricing of these securities - a fact that follows from the assumption of complete market access of *all* market participants. The newly issued debt security is then a redundant asset, which has in the absence of arbitrage one price that all investors - independent of their demand for risky securities - agree upon. This price is the *arbitrage free price* and this methodology is termed *arbitrage free pricing.* As such the demand for risky assets is irrelevant to the decision about the optimal capital structure. This follows from the methodology for derivative pricing

[7]First analyzed by Jones et al. (1984).

[8]This is sometimes termed as the private owner manager has *deep pockets.*

based on the constructive contributions of Black and Scholes (1973) as well as Merton (1973), that was popularised for the pricing of corporate bonds by Merton (1974) and Leland (1994).

However, a bond is only redundant, if either the company's asset portfolio is a traded asset itself or if the company has already issued another security. The former assumption is generally not given.[9] The latter assumption is often only *apparently* given. It is not enough to have another security outstanding, all market participants must also have access to this incumbent outstanding security.[10] If this is the case for none of the investors of the new security, markets are completely segmented. But even if some investors are not subject to market segmentation, the volume of these investors must be large enough in order to drive the price to its arbitrage free level. If this is not the case, markets are weakly segmented.

In segmented markets, arbitrage free pricing is limited or even void and the irrelevance of the investor does not hold. Chen (1995) demonstrated how arbitrage free pricing and equilibrium pricing do not necessarily coincide under market segmentation. This is naturally even true for financial innovations that are pure repacking between segments. This breaks arbitrage free pricing and thus the irrelevance of the investor, and - contrary to most of the capital structure literature - the characteristics of the supply side of the capital market influences the valuation of corporate bonds and thus optimal capital structure.

2.2.2 Anecdotal evidence

Market segmentation in the bond market was first proclaimed by Modigliani and Sutch (1966) as well as Modigliani and Sutch (1967). They observed, that returns earned on government bonds vary significantly across maturities. They put forward their behavioral explanation, that investors differ by time preference. As a consequence their investment opportunity sets differ. This leads to a maturity-induced market segmentation. This theory is labeled as the *preferred habitat theory*.

In the corporate bond market, market segmentation is primarily driven by risk-induced regulations. Some restrictions step in on the buyer's side: A wide range of investors are restricted in their investments, either by government regulations or in their by-laws. A prominent example is, that most of these investors are restricted from adding non-investment grade bonds

[9] It is hardly possible to replicate a company's business model with traded securities and derivatives. It might be approximately true for very specific companies e.g. companies that have a high exposure to commodities, but even in such a case the replication is at best a crude approximation.

[10] The new security must also be written on the same asset portfolio as the incumbent security. If the incumbent and the new security are written on different assets belonging to the same corporation but kept in bankruptcy remote structures, redundancy is not given, even though the company has already a traded security.

to their portfolios.[11] Other restrictions step in on the seller's side: Some issuers are restricted to sell their securities only to *accredited investors,* which usually are investors with a certain size and/or financial sophistication.[12] These primarily risk-induced regulations split the corporate bond market into segments which are in turn risk-induced. It is then not surprising that Miller (1986) argued that market segmentation and the bulk of financial innovations is driven by regulations.

2.2.3 Empirical evidence

The risk-induced market segmentation is supported by overwhelming empirical evidence. Chen et al. (2010) conducted a natural experiment. They investigated *mechanical* changes in ratings due to changes in the construction of a major bond index. They found a significant discontinuity in cumulative abnormal returns between bonds that were upgraded from the non-investment grade segment to the investment grade segment and bonds that stayed in their previous market segment. Chernenko and Sunderam (2012) observed the same discontinuity. By applying a regression discontinuity approach they observed that at the cutoff between the investment grade and the non-investment grade segment, non-investment grade companies are exposed to more variations in the supply and cost of capital than their peers in the investment grade segment. This excess variation is not driven by fundamentals. Kisgen (2006) as well as Kisgen and Strahan (2010) found a significant influence of discrete costs of a change in credit rating on capital structure. Their results are the strongest at the cutoff between investment grade and non-investment grade companies. Also the survey conducted by Graham and Harvey (2001) on what corporations actually consider when they determine their capital structure, lists *our credit rating* as the second highest concern. All these empirical contributions imply that there exists risk-induced market segmentation in the corporate bond market.

[11] For example the *California public employees' retirement system statement of investment policy for global fixed income program,* September 13, 2010 sets limits on investments in individual fixed income segments. Another example are savings association which according to 12 United States Code §1831e(d)(1) (2011) must not hold non-investment grade bonds. See also Kisgen (2006), paragraph I.A, Kisgen and Strahan (2010), paragraph 1.1 for some more examples and Jiang (2010) for a general primer.

[12] Most developed jurisdictions have a definition for accredited investors. Definition in the United States: 15 United States Code §77b(a)(15) (2011). Definition in the European Union: Annex II of Directive 2004/39/EC of the European Parliament and of the Council of 21 April 2004 on markets in financial instruments amending Council Directives 85/611/EEC and 93/6/EEC and Directive 2000/12/EC of the European Parliament and of the Council and repealing Council Directive 93/22/EEC, Official Journal of the European Union, L 145, 30/04/2004 pages 0001 - 0044.

2.2.4 Consequences for capital structure

This regulation, risk and ultimately rating induced segmentation has practical consequences for corporations. Because of the exclusion of some investors from lower market segments - voluntary or mandatory - the supply of capital declines in these lower market segments. The market is *tight* relative to higher segments. This naturally leads to higher cost of debt for corporations operating in the lower segments of the debt market and additionally to an incentive to corporations to stay in higher market segments.

2.3 Generalized trade off model

This section constructs a generalized trade off model that accounts for market segmentation. Subsection 2.3.1 sets up the environment, subsection 2.3.2 introduces the supply schedule of corporate debt capital under complete market segmentation, subsection 2.3.3 introduces the objective function for the optimal capital structure and subsection 2.3.4 provides applications of the generalized trade off model.

2.3.1 General setup and corporate claims

2.3.1.1 Timing and legal environment

The model in this paper is a two period model with only one single company in the market. The approach to capital structure i.e. the demand side of the market for capital, is related to Leland (2007). There are two relevant points in time, namely $t = 0$ and $t = T$. Two legal characteristics that are according to Armour et al. (2009) constructive for a developed economy are assumed to hold within this paper: Companies are subject to limited liability and interest payments are tax deductible. The corporate tax rate is denoted by τ.

As a result of the static nature of the model and limited liability, a company is in default if its liabilities exceed its assets. It is then liquidated following a Chapter 7[13] procedure.[14] Bankruptcy results in two forms of bankruptcy costs: I) the company loses some fixed share α of its asset value[15] and II) the company loses its tax shield[16].

[13] 11 United States Code Chapter 7 (2011).

[14] There is no agency about the timing of the bankruptcy proceedings.

[15] This captures the firesale discount and the procedural costs.

[16] As I have outlined in chapter 1, it is disputed whether this is true. Kim (1978) argues in a similar direction. For an argument, why this is most probably the right assumption I refer the reader to Kim (1978) or to the mentioned exposé.

2.3.1.2 Assets

Corporate assets in this model are denoted by X^t where t is the point in time. The assets are a random cashflow that a company generates at $t = T$ from some business activity. This random cashflow is assumed to be $X^T \sim \mathcal{N}(\mu_X, \sigma_X)$ with $\mu_X \in (0, \infty)$[17] and $\sigma_X \in (0, \infty)$[18]. The cashflow from operations are earnings before interest and taxes (EBIT). The EBIT minus the interest payments are a company's taxable income.

There also exists a risk free rate from $t = 0$ to $t = T$ denoted by r_f^T.

2.3.1.3 Bonds

A bond is a security that promises to pay a fixed amount P at $t = T$. The bond's $t = T$ payoff is denoted by $\xi_B\left(X^T; P\right)$ and its $t = 0$ equilibrium price is denoted by $q^*(P)$[19]. The equilibrium price depends on the market's supply of bonds that is introduced in section 2.3.2. The interest payments are included in the final fixed payment P and there are no interim payments. Bonds in this paper are therefore zero coupon bonds.

The payoff of a bond depends on the promised payment P, on the tax shield and on default. As the taxable income is the EBIT minus the interest payments, a company only pays taxes if the EBIT lies above a *zero tax bound* X_{ZT} which is at

$$X^T \geq X_{ZT} = P - q^* \tag{2.1}$$

This just stipulates that a company only pays taxes if its earnings are above its interest payments. As introduced in section 2.3.1.1, a company is in default, if its liabilities exceed its assets that is if X^T is such that

$$0 \geq X^T - \tau \max\left(X^T - X_{ZT}, 0\right) - P$$

The above condition implies that, if X^T is less than the debt repayments plus the interest and the tax payments, a company is in default. The *default bound* X_D solves therefore

$$0 = X_D - \tau \max\left(X_D - X_{ZT}, 0\right) - P$$

[17] The expected asset value can be decomposed into an annual net asset return r_X by solving $\mu_X = X_0 (1 + r_X)^T$ where X_0 is the size of the company.

[18] The asset volatility can be decomposed into an annual net asset return volatility ς_X by solving $\sigma_X = X_0 \varsigma_X \sqrt{T}$.

[19] From here on forward the argument P - the bonds principal - is suppressed.

The zero tax bound has to be lower than the default bound, otherwise the interest payment would exceed the final fixed payment which is a contradiction. As a result the default bound X_D is at

$$X_D = P + \frac{\tau}{1-\tau} q^* \tag{2.2}$$

Given this bound, the resulting bond payoff has the following structure

$$\xi_B\left(X^T\right) = \left\{ \begin{array}{c} P, \text{ if } X_D \leq X^T \\ X\left(1-\tau-\alpha\right), \text{ if } 0 \leq X^T < X_D \\ 0, \text{ if } X^T < 0 \end{array} \right\} \tag{2.3}$$

Equation 2.3 is the ex post payoff. The ex ante valuation of the bond i.e. the $t = 0$ equilibrium price q^* depends on the supply schedule that will be introduced in section 2.3.2. For this supply schedule and thus the valuation scheme, the expected discounted value and the expected discounted variance of the bond will be necessary. Expressions for these moments are given by equations 2.21 and 2.18 in Appendix I.i to this chapter. Note that the payoff in equation 2.3 implicitly depends on q^* through X_D and X_{ZT}. This lies in the cross dependency between the tax shield and the payoff of the bond. Because of this, there will be no explicit solution to q^* and numerical methods have to be applied.

2.3.1.4 Equity

The equity claim in this model is the residual claim on the assets after the bond is served if the company is solvent, and enjoys limited liability, if the company is in bankruptcy. This yields the following payoff for the residual equity claim

$$\xi_E\left(X^T\right) = \left\{ \begin{array}{c} X^T - P - \tau\left(X^T - X_{ZT}\right), \text{ if } X_D \leq X^T \\ 0, \text{ if } X^T < X_D \end{array} \right\} \tag{2.4}$$

where X_{ZT} and X_D are defined as in equations 2.1 and 2.2. The expected discounted value and the expected discounted variance of the equity claim are given in equations 2.22 and 2.25 in Appendix I.ii to this chapter.

2.3.2 Capital supply to the corporate bond market

2.3.2.1 Approximate linear mean-variance investors

As it was outlined in section 2.2.1, a consequence of segmented markets is the loss of complete market access of all market participants. In this section it is assumed, that markets are completely segmented i.e. every market participant has only access to one market segment. As a consequence of this, a company, that implements its capital structure, is new to the segment, it is considering to issue a security. By adding a new security to a market segment, the company provides a financial innovation to that particular market segment - even if it already has a security trading in another market segment. A financial innovation is not simply a redundant asset, but it enlarges the span of the particular market segment. This fact disables arbitrage pricing and - as a consequence - an assumption on how the market participants supply capital is necessary.

In this paper it is assumed that the market participants are expected utility maximizers that have a constant demand for risky securities (CDRS).[20] Under the above assumption and under the assumption of approximative normality of corporate securities, expected utility maximization is approximately equivalent to linear mean-variance optimization.[21] The working assumption in this paper is therefore, that the market participants that are subject to market segmentation are approximate linear mean-variance optimizers.[22]

2.3.2.2 Equilibrium capital supply within a market segment

Agents that are approximate linear mean variance optimizers, value a corporate security based on its mean μ_S and its variance σ_S. Throughout this paper, optimization problems - including the capital market investor's portfolio selection problem - are expressed in *discounted* terms. Then the T-period risk free rate's expected value equals to once the amount invested. The i^{th} investor's portfolio problem with respect to the corporate security S is

[20] This is equivalent of assuming constant absolute risk aversion (CARA).

[21] See Collins and Gbur (1991) for the exact derivation and Tsiang (1972) as well as Hanson and Ladd (1991) for numerical illustrations for the approximative result.

[22] The assumption of a mean-variance market for corporate capital appears frequently in the literature on corporate finance with frictions. Rubinstein (1973a) assumes a mean-variance market model in his synthesis of portfolio theory and corporate finance theory. It is also assumed by Rubinstein (1973b) and Glenn (1976) in their contributions on segmented markets as well as in Kim (1978)'s analysis on the role of bankruptcy costs for the optimal capital structure. The mean-variance market model also remains widely used in practice on both ends of the market: It is frequently used for capital budgeting as well as for investment management. This is presented in Graham and Harvey (2001) as well as in Fabozzi et al. (2002). It is part of every textbook about portfolio management such as Ramaswamy (2003) for example, and - as presented in Lerner (2003) - its use extends beyond listed securities such as to private equity. Even the laws on investment management are mostly written based on the mean-variance market model, see Bines (1976).

$$\max_{\theta_0^i,\theta_1} \theta_0^i + \theta_1^i \mu_S - \frac{\gamma_i}{2}\left(\theta_1^i \sigma_S\right)^2 \tag{2.5}$$

$$s.t.\ \ \theta_0^i + \theta_1^i q = w_i^0 \tag{2.6}$$

where θ_0^i denotes the number of risk free bonds, θ_1^i the number of risky securities S, q the price of security S, γ_i the i^{th} investor's demand for risky securities[23] and w_i^0 the i^{th} investor's $t = 0$ wealth. The problem in equations 2.5 and 2.6 can be reduced to

$$\max_{\theta_1^i} w_i^0 - \theta_1^i q + \theta_1^i \mu_S - \frac{\gamma_i}{2}\left(\theta_1^i \sigma_S\right)^2 \tag{2.7}$$

The first order condition of the reduced problem in equation 2.7 determines the i^{th} investor's optimal holding of the risky security S which is

$$\theta_2^i = \frac{\mu_S - q}{\gamma_i \sigma^2} \tag{2.8}$$

The overall market demand for the security S is just the sum of the individual holdings. In a capital market equilibrium markets have to clear i.e. supply has to match demand. Without loss of generality, the overall quantity of the risky security S is normalized to one. Then its equilibrium price q^* solves the equation

$$\sum_i \left[\theta_1^i\right] \equiv 1 \Rightarrow \frac{1}{\sum_i [\gamma_i]} \frac{\mu_S - q^*}{\sigma_S^2} \equiv 1 \tag{2.9}$$

Define the aggregated market demand parameter for risky securities as $\Gamma = \sum_i [\gamma_i]$, then the equilibrium price for the security S in a CDRS/mean-variance market is

$$q^* = \mu_S - \sigma_S^2 \Gamma \tag{2.10}$$

2.3.2.3 Risk-induced market segmentation

As presented in section 2.2 there is overwhelming anecdotal and empirical evidence for risk-induced market segmentation in the corporate bond market. This holds especially true for the border between investment grade and non-investment grade bonds. In this paper it is assumed that there exists risk-induced market segmentation in the corporate bond market. In this section this market segmentation is complete, in section 2.4 it is weak.

[23] This is also termed the investor's *coefficient of absolute risk aversion* or the investor's *taste for risk.*

The corporate risk policy in a firm based model is influenced by two elements: By the risk of the operational cashflows and by the risk of leverage. The risk of the operational cashflows is characterized by the distribution of X^T and as such by σ_X. Leverage is characterized by the choice of P i.e. the $t = T$ amount promised to the bondholders. Both risk factors are jointly expressed by a bond's volatility. Additionally, a volatility measurement that maps market segmentation ought to allow to compare different bonds. Denoted Σ_B as the *annualized and discounted volatility of a bond's expected gross returns.* Σ_B serves in this paper as the volatility measurement that maps market segmentation, as it allows to compare different corporate bonds. Remembering that the gross return R_B can be expressed as $R_B = \frac{\mu_B}{q^*}$ where μ_B denotes the bond's $t = T$ expected value and q^* denotes the bond's $t = 0$ equilibrium price, Σ_B is expressed as

$$\Sigma_B = \sqrt{\frac{\sigma^2_{R_B}}{T}} = \frac{1}{\sqrt{T}} \frac{\sqrt{\sigma^2_B}}{\sqrt{(q^*)^2}} \tag{2.11}$$

where $\sigma^2_{R_B}$ denotes a bonds discounted variance of returns, ξ_B the bond's payoff as in equation 2.3 and σ^2_B is the bond's variance. σ^2_B is given by equation 2.21 while the equilibrium price q^* is determined by the supply schedule that is introduced in this section by equation 2.13.

The above parameter Σ_B includes both risk factors of a company, the one from leverage is included by P and the one from the company's operations is included by σ_X. The literature[24] generally agrees that the volatility of bonds increases, when walking down the rating scale. This is primarily a consequence of the higher default rates that bonds with low ratings exhibit.[25] It is therefore consistent to model risk-induced market segmentation by means of Σ_B, as it maps a company's fundamental risk implied in a corporate bond.

Market segmentation is in this section assumed to be *strong* or *complete* i.e. the individual segments of the market do not communicate with each other. Since it is assumed that the investors in this paper exhibit CDRS, the parameter that controls the aggregated capital supply to risky securities is Γ. The market segmentation in this model is drawn by a *segmentation function* $\psi : \Sigma_B \to \Gamma$, that maps a particular risk level Σ_B on a supply level i.e. on a particular Γ. The segmentation function is defined piecewise based on a collection of detachment points that draw the market segments. These detachment points denote the maximum level of risk that may be associated with a bond in order to allow the bond to stay in a particular segment. If a bond

[24] See Reilly and Wright (1997) or Reilly et al. (2009) page 68 for an illustrative and summarizing example and Bao and Pan (2010) for a recent study.

[25] There is a simple economic explanation for this, which lies in the bonds capped and concave payoff structure: While a bond has a limited upside potential because it is capped from above, a bond's potential for variations in expected return is limited. A bond however has a substantial downside potential and as such a large potential for variation in volatility. Among other things, non-investment grade bonds exhaust the latter potential.

surpasses that detachment point, it drops into the next lower segment.

It is assumed that the market is split into three segments, a high grade (HG), a medium grade (MG) and a non-investment grade (NIG) segment. As market segmentation is assumed to materialize along the lines of Σ_B, there are two detachment points that mark the risk-induced boundaries of the market segments. They are denoted by Σ_j, where index $j = \mathrm{HG/MG}$ denotes the detachment point between the high and the medium grade segment and the index $j = \mathrm{MG/NIG}$ the detachment point between the medium and non-investment grade segment. The associated supply levels within the market segments are denoted by $\Gamma_j, j \in \{\mathrm{HG}, \mathrm{MG}, \mathrm{NIG}\}$. The segmentation function is written as

$$\psi\left(\Sigma_B; \mathbf{\Sigma}, \mathbf{\Gamma}\right) = \left\{ \begin{array}{c} \Gamma_{\mathrm{HG}}, \ \text{if} \ \Sigma_{\mathrm{B}} < \Sigma_{\mathrm{HG/MG}} \\ \Gamma_{\mathrm{MG}}, \ \text{if} \ \Sigma_{\mathrm{HG/MG}} < \Sigma_{\mathrm{B}} < \Sigma_{\mathrm{MG/NIG}} \\ \Gamma_{\mathrm{NIG}}, \ \text{if} \ \Sigma_{\mathrm{MG/NIG}} < \Sigma_{\mathrm{B}} \end{array} \right\} \tag{2.12}$$

with Σ_B as in equation 2.11, $\mathbf{\Sigma} = \left(\Sigma_{\mathrm{HG/MG}}, \Sigma_{\mathrm{MG/NIG}}\right)$ and $\mathbf{\Gamma} = (\Gamma_{\mathrm{HG}}, \Gamma_{\mathrm{MG}}, \Gamma_{\mathrm{NIG}})$. In section 2.2.4 it was argued that the main consequence from market segmentation is, that the supply of capital narrows while walking down the rating scale. In order to map the empirical evidence mentioned in section 2.2.4, Γ_j has to increase when walking down the rating scale i.e. $\Gamma_{\mathrm{HG}} < \Gamma_{\mathrm{MG}} < \Gamma_{\mathrm{NIG}}$.

The above approach to model market segmentation is illustrated in figure 2.1. The abscissa depicts the risk level of a bond Σ_B while the y-axis depicts the supply level that is assigned to a risk level. The white, the gray and the dark gray areas depict the HG, the MG and the NIG segment respectively. The segments are detached by the detachment points $\Sigma_{\mathrm{HG/MG}}$ and $\Sigma_{\mathrm{MG/NIG}}$. The dashdotted line illustrates the way a bond takes through the segmentation function: As long as the bond's risk level is below $\Sigma_{\mathrm{HG/MG}}$, the bond is in the HG segment and the supply level Γ_{HG} is assigned to the bond. If the bond's risk level is larger than $\Sigma_{\mathrm{HG/MG}}$ but lower than $\Sigma_{\mathrm{MG/NIG}}$, the bond is in the MG segment and the bond's supply level jumps to Γ_{MG}. If the bond's risk level is large than $\Sigma_{\mathrm{MG/NIG}}$, the supply level jumps to Γ_{NIG}.

INSERT FIGURE 2.1 ABOUT HERE

The approach is in some sense similar to Rubinstein (1973b)'s assumption of markets with different tastes. However, in Rubinstein (1973b) the question is addressed on how the overlap drives a capital structure trade off i.e. on how the Γ that results from the overlaps drives a capital structure trade off. In this paper the overlap is already concentrated in Γ and the segmentation induced discontinuities are the object of interest. In Glenn (1976) it is not explicitly modelled how market segmentation materializes.

2.3.2.4 Equilibrium capital supply with risk-induced market segmentation

The equilibrium capital supply and as such the equilibrium price q^* for a corporate bond in a market which combines the assumption of CDRS agents as in equation 2.10 with market segmentation drawn by a segmentation function $\psi(\Sigma_B)$ as in equation 2.12, is derived as follows: Since market segmentation is modelled by $\psi(\Sigma_B)$ that draws the Γ that is associated with a particular corporate bond, and since the supply within a particular market segment is given by equation 2.10, the bonds equilibrium price under complete market segmentation is given by

$$q^* = \mu_B - \sigma_B^2 \psi\left(\Sigma_B; \mathbf{\Sigma}, \mathbf{\Gamma}\right) \tag{2.13}$$

Expressions for μ_B and σ_B are given in Appendix I.i to this chapter. As opposed to equation 2.10, the supply schedule in equation 2.13 is now the supply schedule of the entire market, that takes into account the market segmentation. The structure of equation 2.13 is basically the bond's expected value μ_B - which corresponds to the arbitrage free value in the literature on capital structure without frictions - minus some discount. This discount reflects the supply restrictions of a particular bond and as such it reflects the *burden of market segmentation* a bond is exposed to. The discount depends on the market's aggregated demand for risky securities Γ which is assigned through the segmentation function $\psi\left(\Sigma_B; \mathbf{\Sigma}, \mathbf{\Gamma}\right)$, and on the bond's variance σ_B. So the discount depends on the supply characteristics of the corporate bond market which are mapped by Γ and implicitly - through the segmentation function - as well as explicitly on the bond's variance σ_B. If $\Gamma_j = 0$, capital supply is infinitely elastic[26] and the friction disappears. The value of the bond is then equal to its expected value which retrieves the standard trade off model. The pricing scheme in equation 2.13 exhibits the following comparative statics: The lower Γ is, the more elastic is the supply of capital and thus the lower is the discount for a bond with fixed principal P.

The supply schedule in equation 2.13 is defined in terms of μ_B, σ_B and $\psi\left(\Sigma_B; \mathbf{\Sigma}, \mathbf{\Gamma}\right)$. These figures implicitly depend on q^* through the tax shield and market segmentation. This creates cross dependencies that were already noted in section 2.3.1.3. Because of that there is no analytical solution to q^* and the model has to be evaluated numerically.

[26]This is equivalent of saying the market has risk neutral utility.

2.3.3 Capital structure decision

It is assumed that at $t = 0$ a company's assets are already in place but no decision has been taken yet on the capital structure. It is further assumed that the company's equity is held by an owner manager that has risk neutral utility.[27] If a bond with principal P is issued, the bond's payoff is given by equation 2.3, the market's aggregated demand for the bond is given by equation 2.13, the payoff of the owner manager's residual equity claim is given by equation 2.4 and the owner manager's valuation of the residual equity claim is given by equation 2.22. The total value $\mathcal{V}(P)$ of a company with a bond outstanding of principal P, is the sum of the value of its claims i.e.

$$\mathcal{V}(P) = q^* + \mu_E$$

where μ_E denotes the expected value of the equity claim that is given by equation 2.22.[28] The owner manager maximizes the company's value and thus determines the optimal capital structure by choosing the principal such that[29]

$$P^* = \arg\max_P \{\mathcal{V}(P)\} = \arg\max_P \{q^* + \mu_E\} \tag{2.14}$$

In the maximization problem in equation 2.14 the owner manager trades off the advantage of the tax shield created by issuing a bond against the costs of bankruptcy and the costs resulting from the market's limited demand for the risky bond and market segmentation. The approach presented in this paper is therefore a *generalized trade off* that accounts not only for the tax shield and bankruptcy costs, but additionally for the costs resulting from risk-induced market segmentation. The capital structure trade off does no longer solely depend on the company's characteristics but additionally on the market's characteristics which are mapped by $\psi\,(\,.\,)$.

Note that the owner manager - despite his risk neutral utility - values the bond the same way the market does. This is because the owner manager measures the bond's value in terms of the proceeds the company receives when issuing a bond. This last quantity in turn is the market's willingness to pay q^*.

[27] This implies that equation 2.18 in Appendix I to this chapter represent the owner manager's valuation of his residual equity claim. Note that the owner manager is assumed to be constrained to hold solely the residual equity claim in order to avoid the existence of arbitrage opportunities. According to the view presented here, capital and borrowing constrains to an owner manager are a reasonable assumption and do not have a driving effect on the model.

[28] Remember that the owner manager has risk neutral utility.

[29] There is ex ante no room for agency. An equity maximizing strategy is equivalent to a value maximizing strategy.

2.3.4 Application

2.3.4.1 Parameters

In this part, the model and market structure laid out is applied. Table 2.1 reports values for a first series of parameters that are fixed throughout this paper: The bankruptcy costs α are such, that they match historical recovery rates in two period models, time to maturity T is the median debt maturity of corporate bonds, the tax rate τ is a literature average, the risk free rate per annum r_f is the medium term median of the treasury constant maturity rate that corresponds to T and the size of the company X_0 is set to $X_0 = 100$.

INSERT TABLE 2.1 ABOUT HERE

Table 2.2 reports values for a second series of base case parameters that are fixed throughout this paper unless mentioned otherwise. In their empirical study on capital structure, Schaefer and Strebulaev (2008) gave estimates for the asset return volatilities of companies from different rating classes. The values for the asset return volatilities in table 2.2 follow their estimates with some minor adjustments.[30] I consider a AAA and a AA rated company as a company of the HG segment, a BBB rated company as a company of the MG segment and a B rated company as a company of the NIG segment.[31]

INSERT TABLE 2.2 ABOUT HERE

Because of the comprehensive application of bond pricing models in empirical studies, that include the assumption of the *irrelevance of the investor,* the expected values corresponding to the asset return volatilities above are typically not observed. Potential proxies for asset returns are returns on commodity or real estate indices. The FTSE NAREIT real estate indices family exhibits pretty stable long term annual returns of 10% on all levels except for mortgages.[32] Greer (2000) presents an empirical study on long term returns on commodity indices and finds roughly the same numbers. Variations in asset quality are in this model primarily implemented through variations in asset volatility.

Market segmentation in this model is induced by the risk associated with a corporate bond, which is implemented by $\psi\left(\Sigma_B; \mathbf{\Sigma}, \mathbf{\Gamma}\right)$. Although the literature[33] agrees on the trend of bond volatility, when walking down the rating scale, there is less agreement on the size of bond volatility

[30] The estimates of Bao and Pan (2010) for the asset return volatility lie in a similar order of magnitude, but they are not pinpointed down to ratings as detailed as in Schaefer and Strebulaev (2008).

[31] This is how the market is generally understood, see e.g. Fabozzi et al. (1997) page 226.

[32] Source: http://returns.reit.com/returns/DomesticReturns.pdf, Accessed July 08, 2011.

[33] See footnote 24.

and as such on the detachment points between the market segments. Of course this is partly in the nature of things as the volatility is not directly observable. Another part of the problem is - as outlined carefully by Bao and Pan (2010) - that there is considerable excess volatility in corporate bond returns, that persists over the different rating classes and decreases with the sampling frequency. This excess volatility is a *surplus* in the sense, that it is not explained by pure default risk. This is however the only source of risk of a corporate bond in a firm based model. Reilly and Wright (1997) observed a volatility of about 3.5% for HG securities such as mortgages, 4% for MG securities and 5% for upper level NIG securities[34]. These figures lie in the same order of magnitude as the estimates of Bao and Pan (2010), which are corrected for the excess volatility. The observations of Reilly and Wright (1997) are most probably based on low frequency data. Since the detachment points ought to lie on the border between the segments and based on the work of Reilly and Wright (1997) as well as Bao and Pan (2010), the detachment point $\Sigma_{HG/MG}$ between the HG and the MG segment ought to be at about 3.75% and the detachment point $\Sigma_{MG/NIG}$ between the MG and the NIG segment ought to be at about 4.5%

Finally, the aggregated market demand parameter for the MG market segment Γ_{MG}, is set such that it matches the average observed leverage of a BBB company as indicated in Schaefer and Strebulaev (2008). In the HG segment, Γ_{HG} is low - only half its MG value - in order to model the high supply elasticity in this market segment and in order to be close to the standard trade off model. In the NIG segment, Γ_{NIG} is double the MG value in order to model the regulatory and risk-induced capital constraints in the NIG segment.

Compared with estimates from the asset allocation and the insurance literature, the values above are rather low: Eisenhauer and Ventura (2003) have stable estimates around 0.18. An exception is Paun et al. (2007) that have estimates for the Romanian stock market that match the assumptions on the Γ's in this paper. The reason for these resulting low values of Γ that matches observed leverage ratios lies in the nature of the firm based model: It is frequently observed, that these type of models underestimate spreads of corporate bonds while maintaining adequate leverage ratios.[35] This - together with the assumption that the equity holder meets a potential financing gap - requires a high aggregated market demand for risky securities and thus a low Γ in order to match observed leverage ratios.

Babcock et al. (1993) provide an overview over the estimates for Γ that have been proposed

[34] *Upper level NIG securities* are bonds that have ratings of BB or B. Ratings of CCC and below are low level NIG bonds.

[35] See Jones et al. (1984) for the first analysis and Leland (2009) for an illustrative summary. Even in the extended model of Demchuk and Gibson (2006) the market price of risk remains rather small.

in the literature on production theory. These estimates are rather disperse ranging from values in the neighborhood of the estimates of the asset allocation literature to values well below to what is assumed in this paper. The average estimate in the literature on production theory is therefore closer to what is assumed in this paper than the average estimate form the literature on asset allocation. A sensitivity analysis with respect to Γ is provided in section 2.3.4.4.2.

2.3.4.2 Capital structure within a market segment

As an introduction, figure 2.2 illustrates the generalized trade off model within a market segment, i.e. with only one value for Γ. Figure 2.2(a) presents the capital structure trade off i.e. the total company value $\mathcal{V}$ as a function of leverage, for a set of aggregated market demand parameters Γ for a company with the asset volatility of a *AA* rated company. If Γ equals zero, the standard trade off model is retrieved. This is the solid black line in figure 2.2(a). The dashed, dotted and dashdotted lines in black and grey are the capital structure trade off for the set of Γ's as indicated in the legend to figure 2.2(a). Figure 2.2(a) illustrates how the capital structure trade off is altered in a model with imperfect capital supply. The higher Γ is, the more is the supply of capital constrained and as such the more expensive is debt financing for a company. This materializes itself in lower total company value for a given leverage ratio.

INSERT FIGURE 2.2 ABOUT HERE

As it is visible in figure 2.2(a), this leads to distinct optimal solutions. This is presented in figure 2.2(b), the optimal leverage ratio as a function of Γ. This graph is the envelope of optimal leverage ratios of the trade off graphs in figure 2.2(a). Figure 2.2(b) is consistent with the economic intuition, that companies choose lower leverage, if the demand for their bonds is constrained.

2.3.4.3 The generalized trade off model

2.3.4.3.1 How companies form their capital structure

In figures 2.3 - 2.5 the supply of bonds is constrained and segmented using the structure of equation 2.13 and the parameters in tables 2.1 and 2.2. Figure 2.3 presents the capital structure trade off for companies with the asset volatilities of HG companies in a segmented bond market. In this paragraph, companies are differentiated by their asset volatility as indicated in table 2.2.

Figure 2.3(a) involves a *AAA* rated company. The first panel in figure 2.3(a) presents the capital structure trade off in a frictionless market, this is the grey dashed graph, and for a segmented market, this is the black solid graph. The solid black line in the second panel in figure 2.3(a) indicates in what market segment the respective bond falls i.e. what Γ is assigned by the segmentation function to a *AAA* rated company given the respective leverage ratio. The panels go together, they share the scale on the x-axis. The layout as described above is the same for figures 2.3 - 2.5. As indicated in the first panel of figure 2.3(a), a company with the asset volatility of a *AAA* rated company can take full advantage of its debt capacity and is not constrained by the segmentation bounds. Only if the company takes on suboptimal excess leverage it would drop to the MG segment as indicated in the second panel in figure 2.3(a). This corresponds to the intuition, that a very high rated company with high quality assets is almost not impacted by market segmentation as it operates in the prime segment.

INSERT FIGURE 2.3 ABOUT HERE

Figure 2.3(b) presents the capital structure trade off for a company with the asset volatility of a *AA* rated company. The kinks in the graph in the first panel of figure 2.3(b) indicate the impact of market segmentation on this company. If the leverage ratio of the company surpasses a kink then the company drops in a lower market segment. The first kink in figure 2.3(b), is at the point where the company drops from the HG to the MG segment at about a leverage ratio of 0.44. The second kink is at the point where the company drops form the MG to the NIG segment at about a leverage ratio of 0.48. As a result of the discontinuity in the capital structure trade off induced by market segmentation, it is possible that for some companies, optimal leverage is a corner solution rather than an interior solution. This is exactly what happens to a *AA* rated HG company as it is close to the bound to the MG segment: Optimal leverage is a corner solution at the first kink between the HG and MG and not an interior solution. The company takes into account the market segmentation and restricts its leverage in order to be able to operate in the HG market segment.

This is consistent with the empirical evidence in Kisgen (2006), which confirms the intuitive idea, that rating induced market segmentation is a highly significant decision variable for capital structure, and that the optimal capital structure is for some companies a corner solution rather than an interior solution. It is also consistent and a potential explanation for the finding of the Graham and Harvey (2001) survey with respect to ratings.

Quantitatively the generalized trade off model implies a lower leverage ratio than the standard model: The company with the *AA* asset volatility is restricted to the corner solution and reduces leverage to roughly 0.44 in order to stay in the HG segment. With the same capital supply, but without the kink to the MG segment, the optimal leverage would be at roughly 0.48 which constitutes a reduction in leverage of 8.33%.

Figure 2.4(a) presents the capital structure trade off for a company with the asset volatility of a BBB rated company. The situation is similar to the AA rated company in figure 2.3(b): There are two kinks in the capital structure trade off, only that in this case, the kink between the HG and the MG segment has an almost invisible impact and does not have the power to constraint the company's financing activities. Despite the higher financing costs, it is valuable to the company to surpass the kink between the HG and the MG segment. If the company would stop at the kink it would not generate enough tax shield i.e. the benefits of additional tax shield generated by higher leverage is higher than the additional costs of market segmentation that result from the drop into the MG segment. However, the company's optimal capital structure is again a corner solution, in this case at the kink between the MG and the NIG segment.

That the border between the MG and the NIG segment has a strong segmentation effect has been confirmed by numerous empirical evidence like Chen et al. (2010) and Kisgen (2006). The model in this paper provides an approach to capture this observation.

INSERT FIGURE 2.4 ABOUT HERE

Figure 2.4(b) presents the capital structure trade off for a company with the asset volatility of a B rated company. The asset quality of this company is so bad that market segmentation has almost no effect on its financing activities. The company would have to restrict its leverage too much in order to take advantage of better segments of the bond market. It is more valuable for this company to issue its debt in the NIG segment of the market and take full advantage of the tax shield. Consequently the optimal capital structure has an interior solution.

2.3.4.3.2 Optimal leverage versus asset volatility

Figure 2.5 summarizes figures 2.3 and 2.4 from an optimal leverage perspective. The solid black graph in the first panel in figure 2.5 is the optimal leverage ratio as a function of a company's asset volatility under complete market segmentation. It is the envelope of the capital structure trade off graphs depicted in figures 2.3 and 2.4. The dashed grey graph is the envelope of the standard trade off model.

INSERT FIGURE 2.5 ABOUT HERE

The generalized trade off model implies decreasing leverage with increasing asset volatility similar to the standard model. But in the generalized model the optimal leverage decreases more steeply and has a number of kinks and turning points. This is a result of the constrain in the supply of capital and market segmentation. Market segmentation provides an incentive to some companies to limit their leverage in order to sustain their ratings and thus their access to the better market segment. After a smooth decrease, the envelope graph exhibits a sudden fall at an asset volatility of about 0.18 until the switch in market segment at 0.21 from the HG to the MG segment. In this region between an asset volatility of 0.18 and 0.21, the incentive to companies to constrain their leverage in order to retain their bonds in the HG segment, is active.

At an asset volatility of about 0.21, the costs of constrained leverage and the associated high rating become too high and the segment is switched. After the switch in market segment there is a sudden rise in leverage followed by a smooth decrease until an asset volatility of about 0.23. The sudden rise in leverage is explained by the loss of the incentive to constrain leverage after the switch in market segment.

After an asset volatility of about 0.23, it becomes again valuable to constrain leverage in order to be able to operate in the MG segment. This incentive is valid until an asset volatility of about 0.255 where the costs of constrained leverage are too high and the segment is switched.

This issue is emphasized through figure 2.6. The black solid line in the first and second panel, in figure 2.6 is the annual bond volatility of the optimal bond[36]. In the second panel the grey dashdotted line is the detachment point between the HG and the MG market segment while the grey dashed line is the detachment point between the MG and the NIG segment. The solid black line in the third panel of figure 2.6 indicates to what market segment the particular bond is assigned i.e. what Γ is assigned by the segmentation function to a particular optimal bond. The scales on the x-axis of the three panels match.

INSERT FIGURE 2.6 ABOUT HERE

Similar to the graph of the optimal leverage ratio in figure 2.5, the graph of the volatility of the optimal bond has turning points and kinks near the detachment points. The graph of the annual bond volatility of the optimal bond visualize the result of the leverage reduction, that companies close to the detachment points implement. As illustrated in the second panel of figure 2.6, the leverage reduction prior to the detachment points allows a company to keep the volatility of the optimal bond below the detachment points indicated by the dashed and dotted lines. When the costs of the leverage reduction becomes too high, the segment is switched, the optimal leverage ratio jumps, which causes the jump in the volatility of the optimal bond.

The general trend of figure 2.5 towards lower leverage than the standard model implies, is consistent with the *under leverage puzzle* investigated by Miller (1977) and Graham (2000) and

[36]The bond that implements the leverage ratio capital structure.

is partly driven by imperfect demand for risky assets. But additionally, for certain companies - but not all - optimal leverage falls even steeper. However, as opposed to the idea of credit rationing such as in Stiglitz and Weiss (1981), it is not the market that is redlining companies on capital, but companies themselves constrain their leverage as a result of their incentive to stay in a higher market segment. This results in apparently underleveraged companies as a natural feedback effect of the segmented structure of the corporate bond market.

Kisgen (2006) presents differentiated evidence: He found strong evidence of an incentive to constrain leverage, when companies are close to a switch in market segments. This is exactly the behavior that the model in this paper rationalizes, by recognizing a market induced feedback effect on corporate leverage policies. The model is also consistent with the survey of Graham and Harvey (2001) which found, that ratings have a sustainable influence on corporate leverage policies.

2.3.4.4 Sensitivity analysis

2.3.4.4.1 Sensitivity to the asset rate of return

This section analyzes the model's sensitivity to two parameters that were kept fixed in section 2.3.4.3, namely the annual asset return and the market's aggregated demand for risky securities.

Figure 2.7(a) presents the sensitivity analysis with respect to the annual asset return. The surface of figure 2.7(a) is the company's optimal leverage ratio as a function of the annual asset return on the x-axis and the annual asset volatility on the y-axis. The surface exhibits two trenches, at the region where the surface changes from dark blue to cyan and at the region where the surface is light green. These *leverage trenches* are the three dimensional representation of the pattern that was observed in section 2.3.4.3.2, that a company constrains its leverage if it is close to a segmentation bound.

INSERT FIGURE 2.7 ABOUT HERE

This is emphasized in figure 2.7(b), which presents the surface of the annual volatility of the optimal bond as a function of the annual asset return and the annual asset volatility. The steps in the surface i.e. the regions of the surface where the surface remains flat, indicate the regions, where the company's incentive to constrain leverage in order to keep its optimal bond in the superior market segment is active. The pattern, that companies have an incentive to constrain their leverage, if they are close to the segmentation bounds, is therefore preserved under variations of the annual asset return.

2.3.4.4.2 Sensitivity to the market's aggregated demand for risky securities

For the sensitivity with respect to the market's aggregated demand for risky securities, a similar situation presents itself. Both, the optimal leverage surface in figure 2.7(c) as well as the annual bond volatility surface 2.7(d), exhibit leverage trenches similar to figures 2.7(a) and 2.7(b). The incentive of companies to constrain leverage close to the segmentation bounds is therefore also preserved under gentle variations of the market's aggregated demand for risky securities.

2.4 Weak market segmentation

In this section it is assumed that markets are *weakly segmented* i.e. that some market participants have full market access while other market participants remain subject to market segmentation. These *arbitrage traders* that have full market access, are able to trade the residual equity claim and exploit this fact strategically. As the arbitrage traders are not subject to the market friction, to them the bond is approximately a redundant asset[37]. Thus their valuation of the bond corresponds to the arbitrage free valuation in a frictionless market. This creates an arbitrage opportunity for them between the equilibrium valuation of the market participants that remain subject to market segmentation and their own assessment of the bond's value.

2.4.1 Empirical evidence

If a form of weak market segmentation ought to exist, then a considerable arbitrage activity ought to be observed. This is indeed the case: It is known under the term *capital structure arbitrage*[38] and it is a relative value arbitrage strategy conducted primarily by hedge funds i.e. participants with a good market access. It is the goal of this arbitrage strategy to explore arbitrage opportunities between different corporate claims of the same company.

As capital structure arbitrage is a hedge fund strategy, its volume is not easy to be quantified directly. However, anecdotal evidence in Berndt and Veras de Melo (2003) indicates, that the activities are substantial.[39]

To my knowledge, the only empirical analysis that analyses the importance of arbitrage capital to the corporate bond market is Choi et al. (2010). Although their focus lies primarily on convertible bonds, there is also some straight debt included in their data. They simultaneously

[37] Redundancy is not exact as in bankruptcy, the bondholder is protected against $X_T \leq 0$ through limited liabilities. It is assumed that the probability of $X_T \leq 0$ is small enough in order to provide a reasonable replication.

[38] Berndt and Veras de Melo (2003) as well as Yu (2006) give a good overview on the essence of this strategy.

[39] Note that this evidence of course dates back until before the late 2000s financial crisis.

investigate demand and supply of corporate bonds over somewhat more than ten years, which includes at least three market downturns[40]. They found that the measures for the flow of arbitrage capital, that they construct, have a significant influence on the supply of corporate bonds. Moreover, during the 2008 short selling ban which essentially precluded some directions of capital structure arbitrage, they measure an immediate and significant downward jump in the proceeds from straight as well as from convertible bond issuance. The flow of arbitrage capital is a significant control to a company's demand for capital and issuance activity. This documents that a weak form of market segmentation exists in the corporate bond market: In a frictionless market the irrelevance of the investor implies a shift in the volume, that a particular class of investors generate, should not influence the quality of the corporate bond market. This is impressively rejected by the empirical evidence in Choi et al. (2010).

Bajlumy and Larsenz (2007) report that i) the gains from capital structure arbitrage are the largest in the NIG segment and ii) that the arbitrage gains cannot be explained by market factors. The former point is consistent with what is postulated in this paper, namely that the costs of market segmentation - and thus the potential arbitrage gains - are the higher the lower the market segment. The latter point reinforces the existence of arbitrage activity, as arbitrage gains are logically not related to market performance factors.

2.4.2 The arbitrage trader's activities

In this section it is explored, how the generalized trade off is altered if some - but not all - market participants are able to trade the residual equity claim and exploit this fact strategically. As it was outlined earlier, the arbitrage trader's[41] ability to trade the residual equity claim allows him to replicate the bond. This ability in turn cancels the friction of market segmentation for the arbitrage trader and enables him to apply arbitrage free valuation. He therefore values the bond at the value it has in a frictionless market, which corresponds to μ_E of equation 2.22.

It is assumed that for all j market segments that $\Gamma_j > 0$, i.e. the remaining market participants are subject to market segmentation.[42] It is further assumed that the arbitrage trader is capital constrained i.e. he may at maximum hold a fraction $0 \leq \bar{\theta}_B^A \leq 1$ of the company's bonds. Finally, it is assumed that the arbitrage trader acts strategically insofar as he arbitrages as much as possible i.e. he always uses his full arbitrage capacity $\bar{\theta}_B^A$ in order to generate as much arbitrage

[40] The LTCM-crisis in 1998, the burst of the tech-bubble in 2001 as well as the late 2000s financial crisis.

[41] It is assumed from here on forward that there is one representative arbitrage trader for a continuum of arbitrage traders.

[42] For $\Gamma_j = 0$ for all j market segments, the ex ante value of the bond would already be at the arbitrage free value as $\Gamma = 0$ corresponds to a frictionless market.

gains as possible.

If the arbitrage trader remains passive, the bonds equilibrium price is drawn by equation 2.13 and - as a result of $\Gamma_j > 0$ for all j - the equilibrium price satisfies $q^* < \mu_B$. This constitutes an arbitrage opportunity for the arbitrage trader. From his perspective the bond is undervalued. But the arbitrage trader's activities influence the other market participant's valuation. Although the arbitrage trader also pays the equilibrium price for his share of the bond, the arbitrage trader's holdings reduce the volume the restricted market participants have to absorb by $\bar{\theta}_B^A$. This in turn alters the market clearing condition in equation 2.9. The market clearing condition in the presence of arbitrage activity is

$$\frac{1}{\Gamma_j} \frac{\mu_S - q^*}{\sigma_S^2} = 1 - \bar{\theta}_B^A$$

Considering the equation for the equilibrium price in a segmented bond market of equation 2.13, the equilibrium price of a bond in a weakly segmented market with an arbitrage activity in excess of $\bar{\theta}_B^A$ reads

$$q^* = \mu_B - \sigma_B^2 \psi \left(\Sigma_B; \mathbf{\Sigma}, \mathbf{\Gamma} \right) \left(1 - \bar{\theta}_B^A \right) \tag{2.15}$$

For the case $\bar{\theta}_B^A = 1$ the arbitrage trader buys up the entire market and neutralized the friction. For $\bar{\theta}_B^A \in (0, 1)$ market segmentation still drives the equilibrium bond price, but it is weakened by the power of the arbitrage trader. For $\bar{\theta}_B^A = 0$ equation 2.13 is retrieved.

2.4.3 Optimal capital structure in a weakly segmented market

The capital structure is in this section still determined according to equation 2.14, only that it is now equation 2.15 and not longer equation 2.13 that derives the equilibrium prices of the bond. First note that q^* increases as $\bar{\theta}_B^A$ increases. This is consistent with the economic intuition, that the costs of market segmentation are the lower the less markets are segmented. This is equivalent to saying that the costs are the higher, the less pronounced the arbitrage trader's activities are, which is a natural consequence of the absence of the irrelevance of the investor.

This has direct consequences to a company and its capital structure trade off. As q^* increases with $\bar{\theta}_B^A$, a company would have an incentive to attract arbitrage activity. However, for the purpose of this subsection, it is assumed that $\bar{\theta}_B^A$ is exogenous.

Figure 2.8(a) illustrates the generalized trade off for a company with the asset volatility of a BBB rated company for different levels of arbitrage activity. The grey dashed line indicates the standard trade off. The solid black line indicates the generalized trade off in a completely segmented market as in section 2.3. The black solid line and the grey dashed line correspond together to the first panel in figure 2.4(a). Similar to figure 2.4(a), the second panel in figure 2.8(a) and 2.8(b) indicate the market segment i.e. the Γ that is assigned to a particular bond. The black dashed, dotted and dashdotted graphs indicate the company's generalized trade off for different levels of arbitrage activity.

INSERT FIGURE 2.8 ABOUT HERE

As it is made visible in figure 2.8(a) with an increasing level of $\bar{\theta}_B^A$, the effects i.e. the costs of market segmentation are weakened. This is consistent with the economic intuition, that arbitrage activities help to improve the quality of the markets by weakening the obstacles such as market segmentation. If the arbitrage trader acquires 75% of the bond - this is the black dashdotted line - the costs of market segmentation becomes almost irrelevant.

This point is further illustrated in figure 2.8(b). The grey dashed line in the first panel of figure 2.8(b) indicates the optimal leverage ratio of a company with the asset volatility of a BBB rated company in a frictionless market, while the grey dashdotted line indicates the optimal leverage ratio of the same company in a completely segmented market. The solid black line indicates the optimal leverage ratio in a weakly segmented market, depending on the level of arbitrage activity $\bar{\theta}_B^A$. From left to right in figure 2.8(b), the market converges from a completely segmented market to a frictionless market. As indicated by the black solid graph, the costs of market segmentation first decline on a very low scale in figure 2.8(b) until about an activity level of $\bar{\theta}_B^A = 0.755$. At this point the costs of market segmentation are low enough such, that the company's incentive to constrain leverage in order to stay in the MG market segment vanishes. The value of additional tax shield generated by a higher leverage ratio, surpasses the additional costs of market segmentation at $\bar{\theta}_B^A = 0.77$. Consistent with economic intuition, the importance of and the costs from market segmentation decline with the market's convergence to a frictionless market.

2.4.4 The RELEVANCE of the investor

The question arises, whether there is evidence, that companies take the arbitrage activity into account as it is postulated in section 2.4.3. In the absence of the irrelevance of the investor the degree of arbitrage activity drives the degree of market segmentation and thus the net proceeds a company achieves, when issuing a bond. Consequently, under the model as it is written down in the last subsection, a company has an interest to have $\bar{\theta}_B^A$ as high as possible - the nature of the investors matters.

Whether companies actively pursue this, is difficult to observe in practice. Companies that want to issue additional securities, frequently go on what is termed a *roadshow.* A roadshow is basically a series of investors' presentations with corresponding face to face meetings. It is disputed in the literature, what the purposes of these roadshows are. While Cai et al. (2007) see it as a tool to reduce information asymmetries with respect to the issuing company, Fridson and Garman (1998) see it as a general method to actively attract investors. Fridson and Garman (1998) do not give a specific rationale on why this would be necessary. But it is insofar consistent with the model in this paper, as attracting arbitrage activity could be a potential explanation for these promotion activities.[43]

In the model as written down in this part, companies have an interest to have their capital structure as much arbitraged as possible. As the study of Choi et al. (2010) presents, an arbitrageur's ability to lever his positions is - among other variables - an explaining variable for the supply of arbitrage capital. This of course exposes the arbitrageur to the risk of his own bankruptcy and thus the arbitrageur's continued ownership of the bond is potentially interrupted. An arbitrageur that leaves the market implies a lower $\bar{\theta}_B^A$.

This is what is analysed and modelled in Brunnermeier and Pedersen (2005), the risk that an arbitrageur has to leave the market. They take an overall market perspective and not the perspective of an individual company, and they assume exogenous securities. But in fact Brunnermeier and Pedersen (2005)'s schedule for the equilibrium price of an asset in their equation 6 is equivalent to the equilibrium price in equation 2.15 in this paper, if one sets $\lambda = \sigma_B^2 \psi \left(\Sigma_B; \boldsymbol{\Sigma}, \boldsymbol{\Gamma}\right)$, $S = 1$ and $X(t) = \bar{\theta}_B^A$ in Brunnermeier and Pedersen (2005). Insofar the model in this section could be considered as an extension of Brunnermeier and Pedersen (2005) with endogenized securities that includes the perspective of an individual company's capital structure.

However, since the model in this paper is only a two period model of capital structure, a company is not affected by a subsequent lower $\bar{\theta}_B^A$. But one could imagine - and it is in effect indicated by the empirical evidence provided by Choi et al. (2010) - that a company, that ought to refinance a bond, faces higher financing costs, if the arbitrage activity declines and markets become more segmented.

Recalling that the equilibrium price in equation 2.15 depends positively on the arbitrage ac-

[43]As a matter of fact Fridson and Garman (1998)'s newspaper quote in their footnote 10 which reads "Bonds are sold; they are not bought [...]" could be interpreted to the effect that companies ought to attract the right type of buyer.

tivity $\bar{\theta}_B^A$, and further recalling, that by equation 2.11 the market segment assignation depends negatively on the equilibrium price, it is even possible that a bond changes the segment, if the arbitrage activity declines steeply enough. So it is possible that a *fallen angel* occurs, not because the company's business activities go badly but only because arbitrage activity declines. Now again for a company this would only have a meaning, if it ought to refinance the bond later, which is not part of the model in this paper. But it has consequences for the investors, that are subject to market segmentation. Their own valuation depends positively on the arbitrage activity. This again emphasizes, that the nature of the investor that holds a bond is irrelevant neither to a company nor to an individual investor under a weak as well as under a strong form of market segmentation.

2.5 Conclusion

The importance of rating induced market segmentation in the corporate bond market is established by substantial anecdotal and empirical evidence. This paper contributes to the literature on capital structure by generalizing the trade off model to incorporate market frictions induced by a segmented bond market. In a segmented bond market, the market access of certain - but not necessarily all - investors is restricted and the supply characteristics of the market become relevant for the optimal capital structure. Market segmentation in this paper is two-fold: The segmentation is induced by the risk associated with a corporate bond, and the supply of capital declines with lower market segments.

This type of risk-induced market segmentation leads to discontinuities in the capital structure trade off. Under these discontinuities, for some - but not all - companies the optimal capital structure is a corner solution rather than an interior solution.

Companies that are close to a segmentation bound have an incentive to constrain their leverage in order to remain in the higher market segment. This leads to apparently underleveraged companies and provides a new rationale to the *underleverage puzzle.*

Under weak market segmentation, the degree of arbitrage activity is an additional parameter, that influences the capital structure of an individual company. This empirically significant arbitrage activity mitigates parts of the costs of market segmentation to companies as the market converges from a completely segmented to a frictionless market. If arbitrage activity is strong enough, the incentive to underleverage eventually disappears.

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Appendix

I Moments for corporate securities

Let $X \sim \mathcal{N}(\mu_X, \sigma_X)$. Denote the associated density function by $\phi(x; \mu_X, \sigma_X)$ and the associated cumulative distribution function by $\Phi(x; \mu_X, \sigma_X)$. The standard normal density function and distribution function are denoted by $\phi(x)$ and $\Phi(x)$. The following definitions follow from Winkler et al. (1972) equation 2.6 and the subsequent lines on page 292:

$$G(a, b, \mu_X, \sigma_X) \equiv \int_a^b x\phi(x; \mu, \sigma)\, dx = \mu_X \left(\Phi\left(\frac{b - \mu_X}{\sigma_X}\right) - \Phi\left(\frac{a - \mu_X}{\sigma_X}\right)\right) - \sigma_X \left(\phi\left(\frac{b - \mu_X}{\sigma_X}\right) - \phi\left(\frac{a - \mu_X}{\sigma_X}\right)\right) \tag{2.16}$$

$$V(a, b, \mu_X, \sigma_X) \equiv \int_a^b x^2\phi(x; \mu, \sigma)\, dx = \left(\mu_X^2 + \sigma_X^2\right)\left(\Phi\left(\frac{b - \mu_X}{\sigma_X}\right) - \Phi\left(\frac{a - \mu_X}{\sigma_X}\right)\right) + \sigma_X(\mu_X + a)\,\phi\left(\frac{a - \mu_X}{\sigma_X}\right) - \sigma_X(\mu_X + b)\,\phi\left(\frac{b - \mu_X}{\sigma_X}\right) \tag{2.17}$$

i Bond

The payoff of a T-period discount bond is given by equation 2.3. If X is the company's only asset, the expected discounted value of a bond with principal P is

$$\mu_B = \left(\frac{1}{1 + r_f^T}\right)\mathbb{E}\left[\xi_B(X)\right] = \left(\frac{1}{1 + r_f^T}\right)\left((1 - \tau - \alpha)\int_0^{X_D} x\phi(x; \mu_X, \sigma_X)\, dx + \int_{X_D}^{\infty} P\phi(x; \mu_X, \sigma_X)\, dx\right)$$

Applying equation 2.16 yields

$$\mu_B = \left(\frac{1}{1 + r_f^T}\right)\left((1 - \tau - \alpha)\, G(0, X_D, \mu_X, \sigma_X) + P\left(1 - \Phi(X_D; \mu_X, \sigma_X)\right)\right) \tag{2.18}$$

where X_D is defined in equation 2.2.

The same bond's discounted variance is given by

$$\sigma_B^2 = \left(\frac{1}{1 + r_f^T}\right)^2\left(\mathbb{E}\left[(\xi_B(X))^2\right] - \left(\mathbb{E}\left[\xi_B(X)\right]\right)^2\right) = \left(\frac{1}{1 + r_f^T}\right)^2\left(\mathbb{E}\left[(\xi_B(X))^2\right] - \mu_B^2\right) \tag{2.19}$$

All terms of the above equation except for the first part of the difference are known. Applying the definition of the expected value operator

$$\mathbb{E}\left[(\xi_B(X))^2\right] = (1-\alpha-\tau)^2 \int_0^{X_D} x^2\phi\left(x;\mu_X,\sigma_X\right)dx + P^2\int_{X_D}^{\infty}\phi\left(x;\mu_X,\sigma_X\right)dx \tag{2.20}$$

Combining equations 2.19 and 2.20 and applying equations 2.16 and 2.17 yields

$$\sigma_B^2 = \left(\frac{1}{1+r_f^T}\right)^2\left((1-\tau-\alpha)^2 V\left(0,X_D,\mu_X,\sigma_X\right) + P^2\left(1-\Phi\left(X_D;\mu_X,\sigma_X\right)\right) - \mu_B^2\right) \tag{2.21}$$

ii Equity

The payoff of the residual equity claim of a company with a bond outstanding with principal P is given by equation 2.4. If X is the company's only asset, the expected discounted value of the residual equity claim is

$$\mu_E = \left(\frac{1}{1+r_f^T}\right)\mathbb{E}\left[\xi_E(X)\right] = \left(\frac{1}{1+r_f^T}\right)\left((1-\tau)\int_{X_D}^{\infty} x\phi\left(x;\mu_X,\sigma_X\right)dx + \int_{X_D}^{\infty}\left(\tau X_{ZT}-P\right)\phi\left(x;\mu_X,\sigma_X\right)dx\right)$$

Applying equation 2.16 yields

$$\mu_E = \left(\frac{1}{1+r_f^T}\right)\left((1-\tau)G\left(X_D,\infty,\mu_X,\sigma_X\right) + \left(\tau X_{ZT}-P\right)\left(1-\Phi\left(X_D;\mu_X,\sigma_X\right)\right)\right) \tag{2.22}$$

The same equity claim's expected discounted variance is given by

$$\sigma_E^2 = \left(\frac{1}{1+r_f^T}\right)^2\left(\mathbb{E}\left[(\xi_E(X))^2\right] - \left(\mathbb{E}\left[\xi_E(X)\right]\right)^2\right) = \left(\frac{1}{1+r_f^T}\right)^2\left(\mathbb{E}\left[(\xi_E(X))^2\right] - \mu_E^2\right) \tag{2.23}$$

All terms of the above equation except for the first part of the difference are known. Using the binomial theorem yields for this term

$$\mathbb{E}\left[(\xi_E(X))^2\right] = \left(\frac{(1-\tau)^2}{(1+r_f^T)^2}\right)\int_{X_D}^{\infty} x^2\phi\left(x,\mu_X,\sigma_X\right)dx + 2\left(\frac{(1-\tau)}{(1+r_f^T)^2}\right)\int_{X_D}^{\infty}\left(\tau X_{ZT}-P\right)x\phi\left(x,\mu_X,\sigma_X\right)dx +$$

$$\left(\frac{1}{(1+r_f^T)^2}\right)\int_{X_D}^{\infty}\left(P^2-2PX_{ZT}\tau+X_{ZT}^2\tau^2\right)\phi\left(x,\mu_X,\sigma_X\right)dx \tag{2.24}$$

Combining equations 2.23 and 2.24 and applying equations 2.16 and 2.17 yields

$$\sigma_E^2=\left(\frac{1-\tau}{1+r_f^T}\right)^2 V\left(X_D,\infty,\mu_X,\sigma_X\right)+\left(\frac{2(1-\tau)}{\left(1+r_f^T\right)^2}\right)\left(\tau X_{ZT}-P\right)G\left(X_D,\infty,\mu_X,\sigma_X\right)+$$

$$\left(\frac{1}{1+r_f^T}\right)^2\left(P^2-2PX_{ZT}\tau+X_{ZT}^2\tau^2\right)\left(1-\Phi\left(X_D;\mu_X,\sigma_X\right)\right) \tag{2.25}$$

II Standard parameters for the model in section 2.3

Standard parameters for the model in section 2.3 (i)				
Description	Parameter	Value	Source	Reason
Bankruptcy costs	α	0.23	Reilly et al. (2009)/Leland (2007)	Matches historical recovery rates in two period models.
Corporate tax rate	τ	0.2	Leland (2007)	Literature average[a].
Risk free rate per year	r_f	0.03	Federal Reserve Bank St. Louis[b]	10 year median 5-year treasury constant maturity rate.
Time to maturity	T	5 years	Bao and Pan (2010)	Med. corporate debt maturity.
Size of the company	X_0	100	Size of the company	The model scales linearly.

[a] There is not much agreement on what the effective tax rate actually is. Some classical papers such as Leland (1994) use the statutory rate which is 0.35 (See 26 United States Code §11(b)(1) (2011)). More recent contributions on structural models such as Arnold et al. (2012) treat 0.15 as a standard. Nicodàme (2001) estimated the effective corporate tax rate at about 0.2 for the United States. The estimate of Markle and Shackelford (2012) lies in the same order of magnitude. This papers follows this estimate. This is inline with Leland (1998) as well as Leland (2007).

[b] http://research.stlouisfed.org/fred2/series/WGS5YR?cid=115, Accessed July 08, 2011.

Table 2.1: Values for parameters of the model in section 2.3 that are fixed throughout the paper.

Standard parameters for the model in section 2.3 (ii)				
Description	Parameter	Value	Source	Reason
An. asset returns for all rating classes	r_X	0.12	Greer (2000)	Long term expected return on real assets proxied by commodities.
Annual asset volatility of a *AAA* company	ς_{AAA}	0.15		Low in order to model securities backed by low volatility assets.
Annual asset volatility of a *AA* company	ς_{AA}	0.2	Schaefer and Strebulaev (2008)	Inferred form table 7.
Annual asset volatility of a *BBB* company	ς_{BBB}	$0.23\frac{1}{2}$	Schaefer and Strebulaev (2008)	Estimate for a *A* company $+\epsilon$
Annual asset volatility of a *B* company	ς_B	0.28	Schaefer and Strebulaev (2008)	Inferred form table 7.
Detachment point *HG/MG*	$\Sigma_{HG/MG}$	$0.03\frac{3}{8}$	Reilly and Wright (1997) & Bao and Pan (2010)	Bond volatility and excess volatility estimates.
Detachment point *MG/NIG*	$\Sigma_{MG/NIG}$	0.045	Reilly and Wright (1997) & Bao and Pan (2010)	Bond volatility and excess volatility estimates.
Aggregated demand for *HG* risky bonds	Γ_{HG}	$\frac{1}{2} \cdot 10^{-3}$		Close to the standard trade off model.
Aggregated demand for *MG* risky bonds	Γ_{HG}	$\cdot 10^{-3}$	Schaefer and Strebulaev (2008)	Matches the leverage ratio of a *BBB* rated company.
Aggregated demand for *NIG* risky bonds	Γ_{HG}	$2 \cdot 10^{-3}$		High in order to model capital constrains.

Table 2.2: Values for parameters of the model in section 2.3 that are fixed unless mentioned otherwise.

III Illustrations for section 2.3

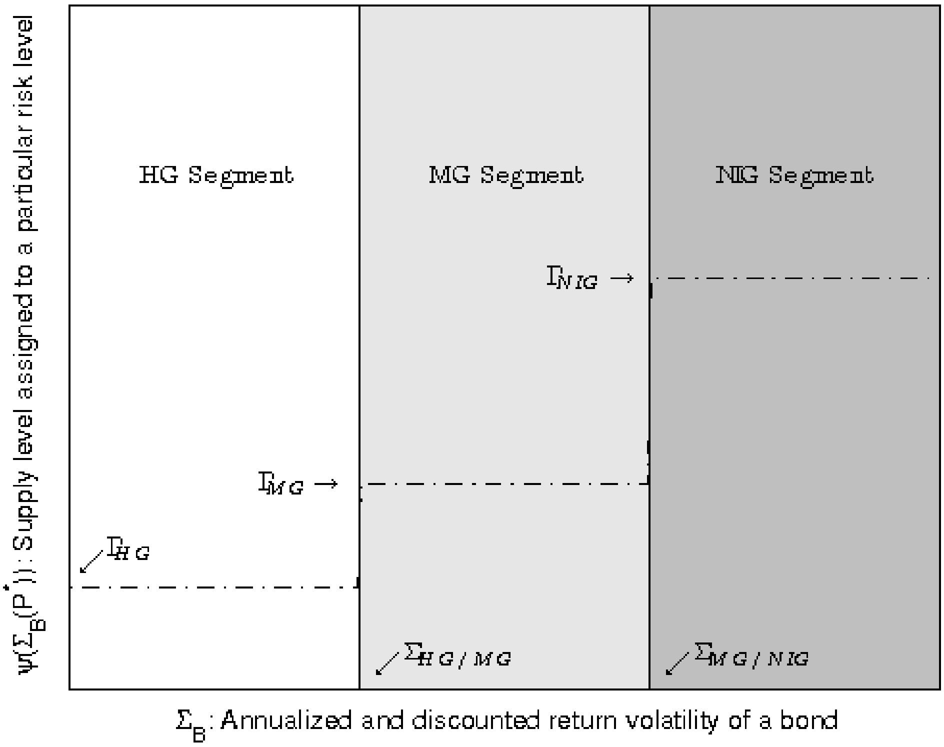
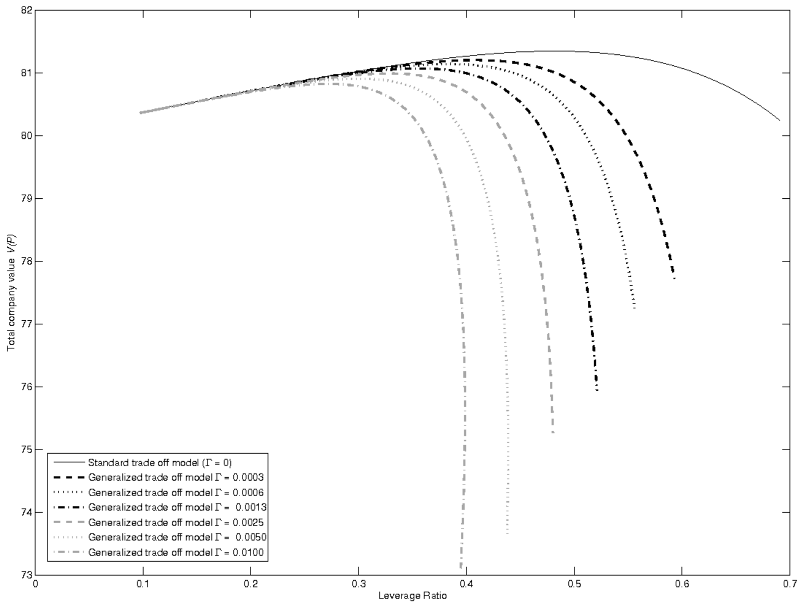
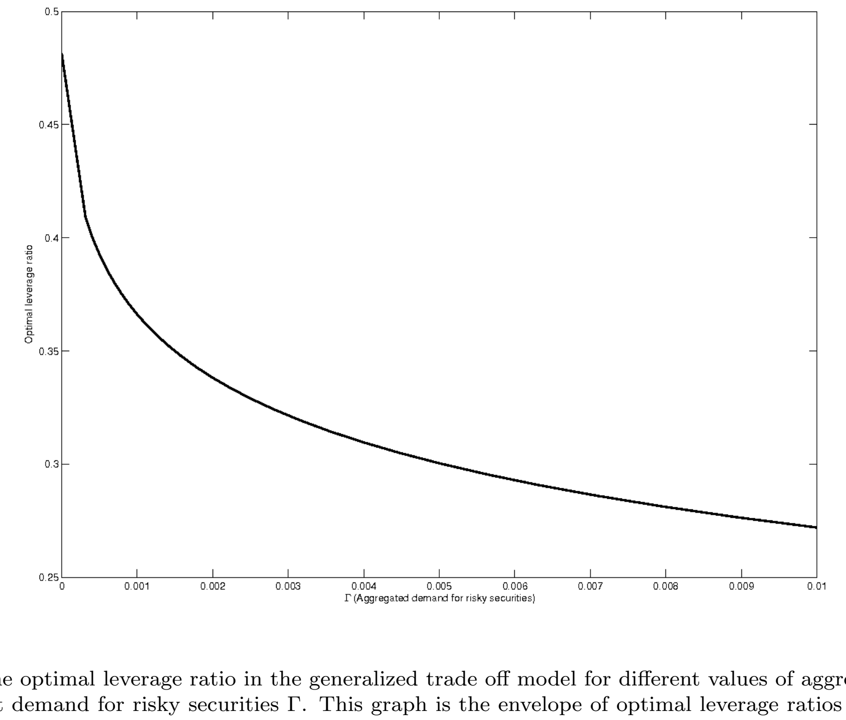


Figure 2.1: Illustration of this paper's approach to model risk induced market segmentation in the corporate bond market. The abscissa depicts the annualized and discounted volatility of a bond's expected gross returns while the ordinate depicts the supply level associated with the respective level of volatility.

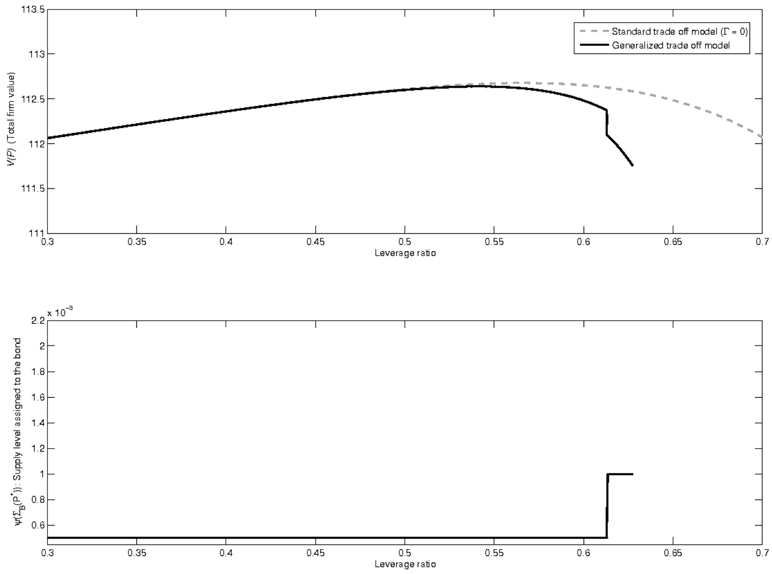


(a) The capital structure trade off in the generalized trade off model for different values of aggregated market demand for risky securities Γ.

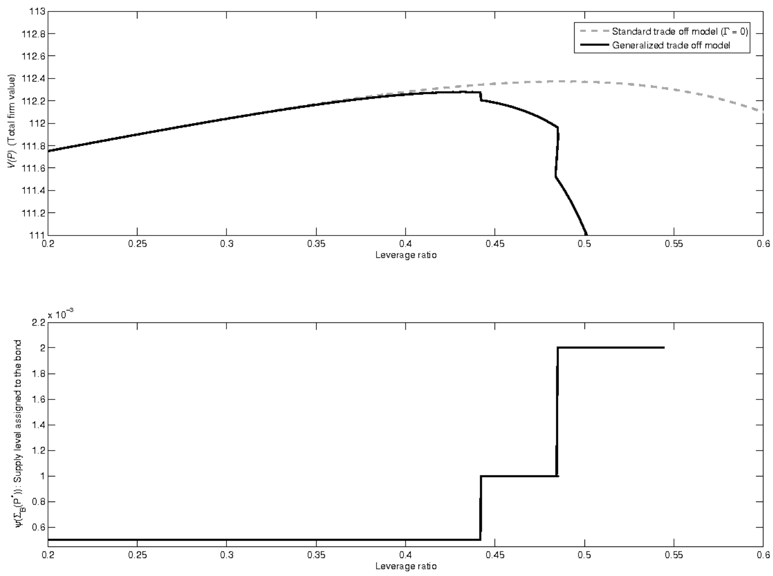


(b) The optimal leverage ratio in the generalized trade off model for different values of aggregated market demand for risky securities Γ. This graph is the envelope of optimal leverage ratios of the trade off graphs in figure 2.2(a).

Figure 2.2: The capital structure trade off and the optimal leverage ratio in the generalized trade off model for different values of aggregated market demand for risky securities Γ.

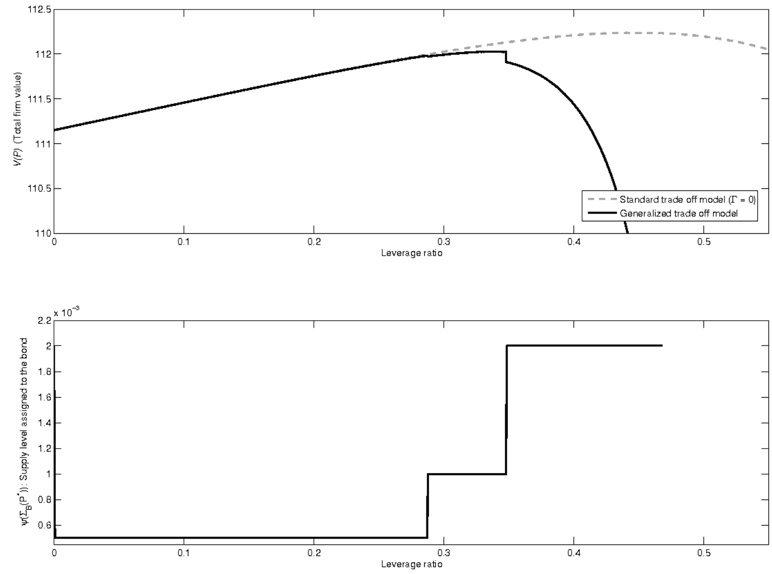


(a) Capital structure trade off and the impact of market segmentation for a company with the asset volatility of a AAA rated company. The first panel depicts the capital structure trade off while the second panel depicts the aggregated market demand for risky securities assigned to the respective bond.

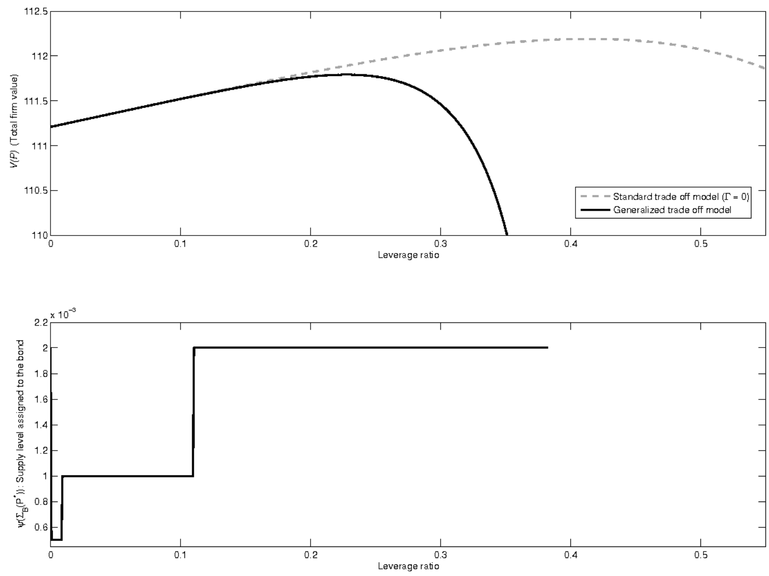


(b) Capital structure trade off and the impact of market segmentation for a company with the asset volatility of a AA rated company. The first panel depicts the capital structure trade off while the second panel depicts the aggregated market demand for risky securities assigned to the respective bond.

Figure 2.3: The impact of market segmentation for HG companies.



(a) Capital structure trade off and the impact of market segmentation for a company with the asset volatility of a BBB rated company. The first panel depicts the capital structure trade off while the second panel depicts the aggregated market demand for risky securities assigned to the respective bond.



(b) Capital structure trade off and the impact of market segmentation for a company with the asset volatility of a B rated company. The first panel depicts the capital structure trade off while the second panel depicts the aggregated market demand for risky securities assigned to the respective bond.

Figure 2.4: The impact of market segmentation for MG and NIG companies.

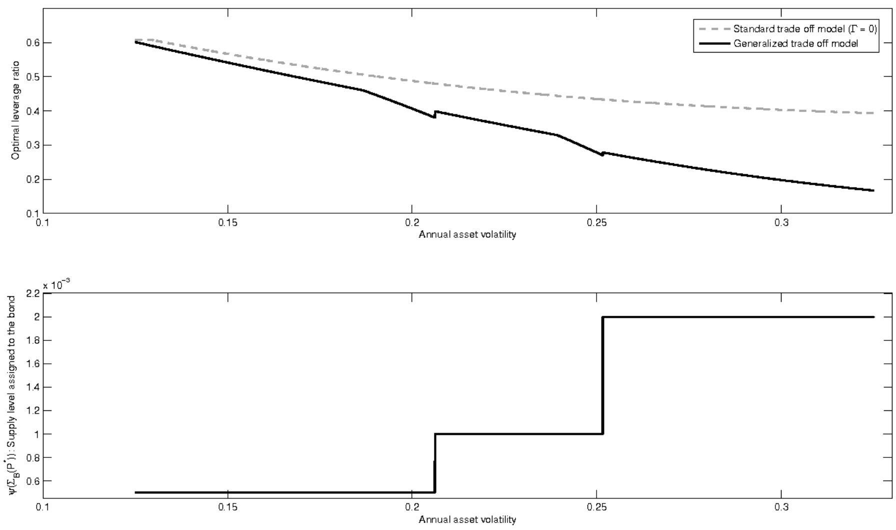


Figure 2.5: Optimal leverage ratios given a company's annual asset volatility in a segmented bond market. The first panel depicts the optimal leverage ratio while the second panel depicts the aggregated market demand for risky securities assigned to the optimal bond. The graph in the first panel is the envelope of optimal leverage ratios of the graphs in figures 2.3 and 2.4.

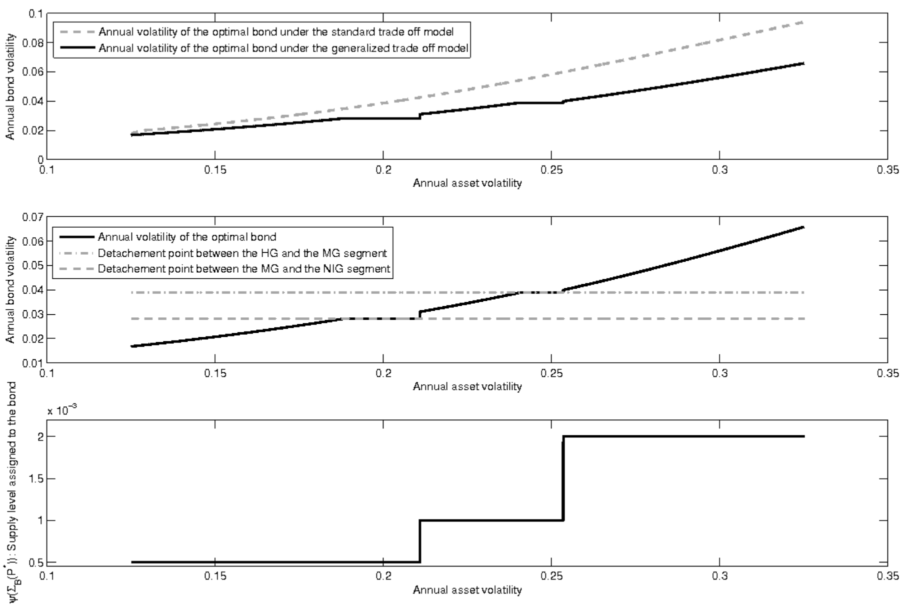
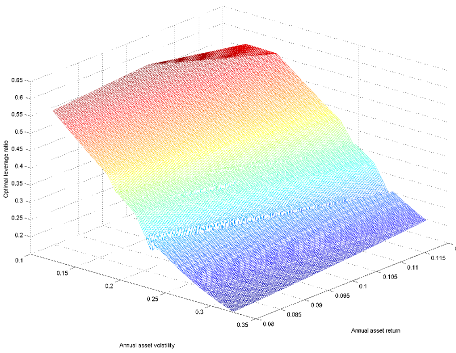
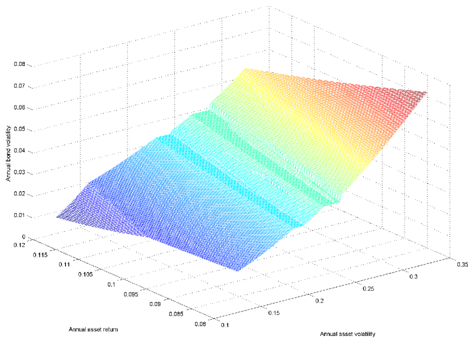


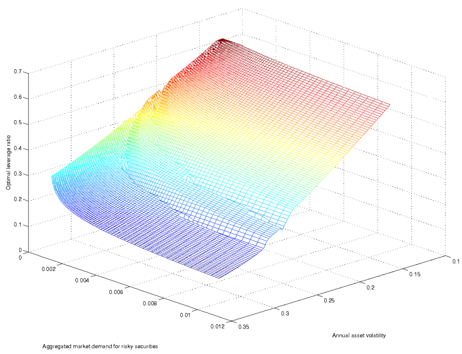
Figure 2.6: Annual volatility of the optimal bonds given a company's annual asset volatility in a segmented bond market. The first and the second panel depict the annual volatility of the optimal bonds while the third panel depicts the aggregated market demand for risky securities assigned to the optimal bond.



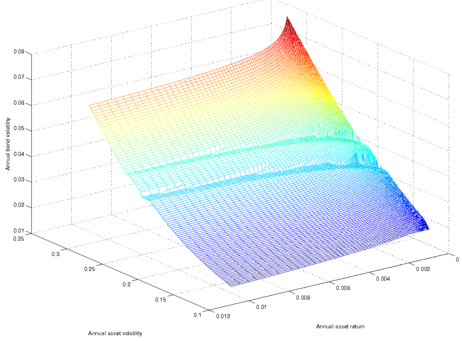
(a) Sensitivity of the optimal leverage ratio to the asset rate of return.



(b) Sensitivity of the annual volatility of the optimal bond to the asset rate of return.



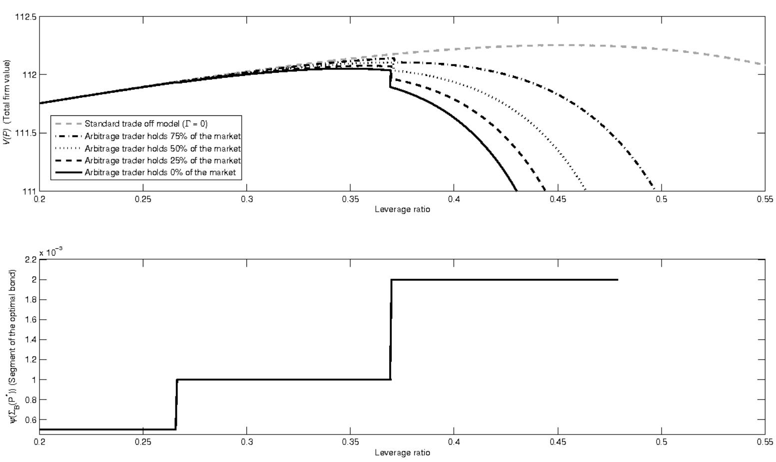
(c) Sensitivity of the optimal leverage ratio to the market's aggregated demand for risky securities.



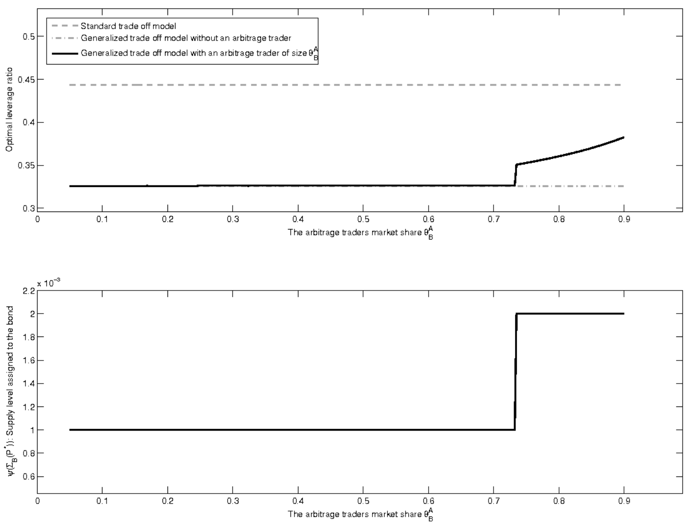
(d) Sensitivity of the annual volatility of the optimal bond to the market's aggregated demand for risky securities.

Figure 2.7: Sensitivity analysis.

IV Illustrations for section 2.4



(a) Capital structure trade off and the impact of market segmentation for a company with the asset volatility of a BBB rated company and different levels of arbitrage activity. The first panel depicts the capital structure trade off for different levels of arbitrage activity while the second panel depicts the aggregated market demand for risky securities assigned to the respective bonds.



(b) The optimal leverage ratio of a company with the asset volatility of a BBB rated company given the degree of arbitrage activity. The first panel depicts the optimal leverage ratio while the second panel depicts the aggregated market demand for risky securities assigned to the optimal bonds.

Figure 2.8: The impact of different levels of arbitrage activity in a segmented bond market on the capital structure trade off and the optimal leverage ratio of a company with the asset volatility of a BBB rated company.

Chapter 3

Capital structure and structured finance in a segmented corporate bond market

Gabriel H. Neukomm[1]

Abstract

Structured finance and securitization have been a large part of the US financial market prior to the late-2000s financial crisis and remain a substantial part until today. Despite this importance the techniques of structured finance, namely tranching and bankruptcy remoteness are not understood very well as they are neutral to a corporate capital structure in a frictionless market. Some contributions on structured finance have pointed out the importance of segmentation in the funding market. This paper analyzes how the techniques of structured finance improve a company's capital structure in a model of capital structure with a segmented corporate bond market. This provides a number of insights on structured finance and securitization, three of which are as follows: First, both tranching and bankruptcy remoteness are techniques that allow a company to access multiple segments of the funding market and thus adjust its capital structure to market segmentation. Second, tranching unlocks additional value and increases optimal leverage for all companies. Consistent with empirical evidence this is particularly powerful for companies with high asset volatility. Third and also consistent with empirical evidence, bankruptcy

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remoteness unlocks additional value and allows for higher optimal leverage exclusively for companies with high asset volatility.

JEL Classification Numbers: G01, G24, G32

Keywords: Capital structure, structured finance, market segmentation

3.1 Introduction

The notion of *structured finance* and *securitization* generally refer to techniques for the issuance of securities that are either backed by assets concentrated in a bankruptcy remote special purpose vehicle (SPV) or that have multiple layers or even both. The primary techniques of structured finance are therefore *tranching* and *bankruptcy remoteness.* Tranching refers to the technique, where a security is split into a cascade of layers that are serviced sequentially. The first tranche - often called the *senior tranche* - is served first. If the senior tranche is fully served, the next tranche is served etc. In a tranched structure, potential losses are therefore absorbed in the other direction starting with the lowest tranche[2]. The lower tranches serve as a cover for the more senior tranches. Bankruptcy remoteness refers to the technique, where a company disunites itself and isolates certain assets from the rest of the company into an SPV. The SPV then issues securities that are exclusively secured with these isolated assets. This creates a structure such, that the SPV's securities are only subject to the bankruptcy risk associated with the SPV's assets and not subject to the residual company's bankruptcy risk. The SPV's securities are bankruptcy remote from the residual company.

The securities issued through the application of these techniques have been a large part of the United States' corporate capital market prior to the late-2000s financial crisis and they remain a substantial part of this market until now.[3] But despite the above empirical facts the rationales for and the techniques of structured finance have not been understood very well and many questions remain open.[4] Among other reasons, this is because in a frictionless and arbitrage free capital market - which is usually assumed in frameworks for capital structure and valuation - the principle of *exposure conservation* applies. Exposure conservation implies that securitization is a zero-sum game: In a frictionless capital market any increase in value of a specific layer of securities or in the securities of an SPV are offset by an equivalent decrease in value of the securities of another layer or of the residual company. Any other outcome would be an arbitrage opportunity.

This paper provides a rationale for the application of structured finance based on the argument, that the corporate bond market is segmented. Based on a simple two period model for capital structure first developed in chapter 2 which incorporates a segmented funding market

[2]The lower tranches are termed *junior, mezzanine* and *equity* tranches, depending on the number of layers.

[3]See for example figure 2 in Benmelech and Dlugosz (2009), figure 3 in Shivdasani and Wang (2011) as well as figures 1 in Benmelech et al. (2012) for some data on the issuance volumes of corporate collateralized loan obligations.

[4]The literature survey on securitization conducted by Gorton and Metrick (2012) provides a list of open question.

for corporate bonds, this paper shows that the techniques of structured finance may improve a company's capital structure under market segmentation. It thus adds to the understanding of the open questions on structured finance that have been highlighted by Gorton and Metrick (2012).

There are already a few contributions that analyze the benefits of structured finance. Schwarcz (1994) claimed that *"...securitization is an alchemy that really works."*[5] without providing an economic foundation. DeMarzo (2005) promotes asymmetric information as a rationale for tranching. In the respective paper it is argued, that with the ability to concentrate the default risk in a specific tranche, the intermediary is enabled to create a senior tranche with substantially reduced sensitivity to asymmetric information. Gorton and Souleles (2007) argue that bankruptcy remoteness is a way to avoid bankruptcy costs. In Oldfield (2000), Benmelech and Dlugosz (2009) as well as in the discussion of Gorton and Souleles (2007)[6] market segmentation in the funding market is put forward as a rationale for structured finance but without providing an economic foundation for this claim.

There is indeed empirical evidence in support of Schwarcz (1994)'s claim: In their comprehensive analysis on CLOs, Nadauld and Weisbach (2012) document that the application of the techniques of structured finance results in lower cost of capital. Maskara (2010) confirms that specifically for tranching, while Ayotte and Gaon (2010) confirm that for bankruptcy remoteness. Maskara (2010) additionally documents, that the benefits of tranching accrue primarily to borrowers with low credit quality. This is confirmed by Rauh and Sufi (2010)'s analysis on the structure of corporate debt, that establishes, that companies with low credit quality are more likely to have multiple debt layers. Benmelech and Dlugosz (2009) analyze the underlying collaterals of CLOs issued prior to the late-2000s financial crisis. They document that the respective collaterals are concentrated around the boundary between the investment grade and the non-investment grade market segment. This paper aims to provide an economic foundation for these stylized facts, especially on how structured finance unlocks additional value and why this seems to be particularly powerful for low credit quality companies.

In the *generalized trade off model* for capital structure developed in chapter 2 and applied in this paper to structured finance, the funding market for corporate bonds is split into segments. The individual segments of the funding market do not communicate with each other i.e. there is complete market segmentation.[7] Market segmentation is *risk-induced* in this model i.e. the

[5] See Schwarcz (1994), page 134. The footnote 2 in Schwarcz (1994) is omitted here.

[6] See the discussion summary in Gorton and Souleles (2007) on page 602.

[7] In chapter 2 it is shown that this strong assumption can be generalized towards weak market segmentation with some degree of arbitrage activity.

market segments are drawn along the lines of the risk level associated with a corporate bond. More specifically, the market segments are defined through a series of cutoff values of bond volatility that draw the bounds of the market segments: If a bond's volatility is higher than a given cutoff value, the bond is assigned to the next lower market segment. The market segments differ in terms of aggregated supply of capital. The supply of capital is assumed to be limited and declining with lower market segments i.e. the lower the market segments, the more costly it is to raise capital.[8] Within this funding market with frictions, the company trades off the benefits of the tax shield versus the bankruptcy costs and additionally accounts for limited aggregated supply of capital. A company's objective function to determine its optimal capital structure is therefore a trade off in the sense of Kraus and Litzenberger (1973), which is generalized for segmentation in the funding market.

In this paper the primary techniques of structured finance, namely tranching and bankruptcy remoteness, are applied within the above model for capital structure under risk-induced market segmentation. A *tranched bond* is in this paper a corporate bond that is split into layers - a *senior tranche* and a *junior tranche* - where the senior tranche has priority over the junior tranche. To issue *bankruptcy remote bonds,* a company disunites itself. For that purpose it is assumed that a company has two kinds of assets in its asset portfolio that differ in asset volatility, namely *low risk assets* with low annual asset volatility and *high risk assets* with high annual asset volatility. If a company issues bankruptcy remote bonds it isolates these two kinds of assets and leverages them separately. This results in two bankruptcy remote bonds, one secured exclusively with low risk assets and one secured exclusively with high risk assets.

In chapter 2 it was shown that if risk-induced market segmentation prevails on the funding market for corporate bonds, this materializes itself in three effects on corporate capital structure: First, as a result of the limited supply of capital in the funding market, leverage is obviously lower under market segmentation. Second, since the market segments are drawn by means of a collection of volatility cutoffs, a company's capital structure trade off exhibits discontinuities. Third, if a company operates close to a bound of the segments in the funding market, a company has an incentive to constrain its leverage in order to preserve its level of capital supply.

The present paper shows how the techniques of structured finance improve a company's capital structure under risk-induced segmentation in the funding market and thus creates a rationale for the application of tranching and bankruptcy remoteness. Key to this insight is, that under

[8]There is comprehensive empirical evidence for this assumption: Kisgen (2006), Kisgen and Strahan (2010) as well as Chen et al. (2010) confirmed the influence of rating changes on corporate capital structures, while Chernenko and Sunderam (2012) confirmed a rating-induced discontinuity in cost of capital at the boundary between the investment grade and the non-investment grade market segment.

risk-induced market segmentation, arbitrage is limited by construction and thus the principle of exposure conservation is potentially violated. Exposure conservation is violated, if the company applies the above mentioned techniques such, that it can access multiple market segments. For tranching that implies that the senior tranche ought to trade in a higher segment than the junior tranche, while it implies for bankruptcy remoteness, that the bond secured with low risk assets ought to trade in a higher segment than the bond secured with high risk assets. It is assumed in this paper that a company only applies these techniques, if they have the potential to cause a violation of exposure conservation.

If a company applies tranching, the value unlocked through the violation of exposure conservation is always positive, as the two layers of its bond allow the company to adjust its leverage more accurately to the segmented funding market. However, tranching remains an imperfect mechanism to mitigate market segmentation, as the individual tranches remain subject to market segmentation. There are thus still discontinuities in a company's capital structure trade off, but tranching reduces their severity. This is similar to what is argued in Oldfield (2000), namely that tranching constitutes an imperfect mechanism to mitigate segmentation in the funding market.

Since capital supply is by construction more constrained in lower market segments, tranching unlocks more value for companies that would otherwise only have access to low market segments. This result is consistent with the empirical evidence in Maskara (2010). It is further consistent with the stylized facts on corporate capital structures analyzed in Rauh and Sufi (2010) and provides an economic foundation for these observations. Tranching also allows a company to maintain a higher optimal leverage. This effect is particularly strong for companies with lower credit quality. This is consistent with the stylized facts in Benmelech and Dlugosz (2009) and provides an economic foundation for this concentration of collaterals. Higher optimal leverage through tranching implies lower cost of capital, which is in turn consistent with the evidence in Nadauld and Weisbach (2012).

If a company applies bankruptcy remoteness, the value unlocked is only positive for companies with low credit quality. Companies with high credit quality decrease their value if they apply bankruptcy remoteness. This has a simple explanation: For companies with low overall credit quality it is valuable to concentrate its low risk assets in order use it as a collateral to access higher market segments. Companies that have a good overall credit quality and already have access to high market segments do not improve their position, if they concentrate their low risk assets. Bankruptcy remoteness is therefore a technique primarily suited for low credit quality companies.

By the same logic that applies to value unlocked, bankruptcy remoteness allows companies with low credit quality to maintain a higher optimal leverage. This effect is particularly strong in the area where a company - without bankruptcy remoteness - would have an incentive to constrain its leverage in order to preserve its level of capital supply. This is because a company that applies bankruptcy remoteness mitigates the above incentive since it concentrates its collaterals according to quality and thus adjusts its capital structure to market segmentation. Higher optimal leverage implies lower cost of capital. The argument here is thus consistent with the empirical evidence in Ayotte and Gaon (2010), where it is found that bankruptcy remoteness is an explaining factor for the funding rates.

The remainder of the paper is organized as follows: Section 3.2 introduces the reader to the techniques of and rationales for structured finance as well as market segmentation. Section 3.3 reviews a generalized trade off model of optimal capital structure that incorporates market segmentation and combines it with the techniques of structured finance. Section 3.4 provides results on the application of structured finance within the model of section 3.3. Section 3.5 relates the results to the late-2000s financial crisis. Section 3.6 concludes.

3.2 Structured finance: Techniques and rationales

3.2.1 Structured finance: Techniques

What is *structured finance*? In Jobst (2007)'s *Primer on Structured Finance* it is described in the following way: *Structured finance encompasses all advanced private and public financial arrangements that serve to efficiently refinance and hedge any profitable economic activity beyond the scope of conventional forms of on-balance sheet securities (debt, bonds, equity) at lower capital cost and agency costs from market impediments on liquidity.* A more narrow definition is found in Leland (2007): *"Structured finance" typically refers to the transfer of [...] a company's assets (an "activity") into a bankruptcy-remote corporation or other special purpose vehicle or entity (SPV/SPE). These entities then offer [...] multiple classes of securities [...].*[9]

The securities issued through the aforementioned entities are called collateralized debt obligations (CDO). Depending on the collaterals, CDO's are classified into subgroups such as residential real estate or commercial real estate CDOs (RRE/CRE CDOs) which are collateralized

[9]Similar definitions are found in Coval et al. (2009) or Schwarcz (1994). This narrow definition of structured finance is also termed *securitization.*

with residential and commercial mortgages, collateralized bond obligations or collateralized loan obligation (CBO/CLO) which are collateralized with corporate loans or corporate bonds and CDO-squared (CDO^2) which are collateralized with other CDOs. The focus of this paper lies on structured corporate loans or corporate bonds i.e. the focus of this paper lies on CBOs or CLOs.

Structured finance and securitization rely on two primary techniques, namely *tranching* and *bankruptcy remoteness*. These techniques are introduced in the following.

3.2.1.1 Tranching

Tranching is the primary form of credit enhancement[10]. This technique imposes a cascade of layers or *tranches* with declining priority on the security i.e. the cashflows generate by the assets that back the security are allocated with declining priority to the tranches. The tranche with the highest priority is called the *senior tranche* and has first rights on cashflows until it is fully funded. When the senior tranche is fully funded, the remaining cashflows fund the next tranche which is called the *junior* or *mezzanine tranche.* Any remaining cashflows after the senior and the junior tranche is funded, fund the last tranche which is called the *equity tranche.* This structure of layers with declining priority is metaphorically termed the *waterfall structure.*

While priority on cashflows is top-down, losses are absorbed bottom up i.e. the equity tranche is the first to absorb losses until it is wiped out. After that, the losses are absorbed by the junior tranche and so forth, and only if all lower tranches are wiped out, then the senior tranche is affected by losses. In effect the lower tranches serve as a cover for the senior tranche.

3.2.1.2 Bankruptcy remoteness

Bankruptcy remoteness is a technique to isolate some of a company's assets from the bankruptcy risk of the residual company and to raise funds based on these individual assets rather than based on the combined company. For that purpose a company disunites itself and spins some of its assets off into an SPV. In order to achieve bankruptcy remoteness of the SPV, the transaction to the SPV has to qualify as a *true sale* under the bankruptcy law[11]. That removes the assets from the residual company's potential bankruptcy estate. Furthermore the SPV's business activities

[10] There are additional techniques of credit enhancement such as overcollateralization, spread accounts or third party guarantees. Overcollateralization is very similar to tranching while the remaining techniques are not considered here.

[11] This first and foremost means that the transaction has to be on *arm length basis.* See for instance Klee and Butler (2002).

are limited to financing activities.[12] The bankruptcy remote SPV is then enabled to use its assets to raise funds by itself and separately from the residual company, while the residual company maintains operational control over the assets of the SPV.[13] The result of the application of this technique is thus, that operational and financial control over assets is separated and the company finances itself *piecewise*.[14]

3.2.2 Structured finance: Rationale

3.2.2.1 Starting point: Traditional models of capital structure

Most contributions and valuation frameworks for capital structure assume that the market for corporate bonds is frictionless. On a frictionless market, the value of a corporate security is only driven by company specific characteristics. Under this frictionless approach, tranching is a value neutral technique: The value gain on the senior tranche is offset by a value decline on the junior tranche. For bankruptcy remoteness it is not entirely clear if it is neutral in a frictionless market. On the one hand, Schwarcz (1994) argues that in the absence of market frictions, the principle of exposure conservation applies and bankruptcy remoteness is neutral. Leland (2007) on the other hand argues, that bankruptcy remoteness may create some value even in a frictionless market, namely if a company's asset portfolio is strongly under diversified.

The conclusion that structured finance is neutral, however conflicts with the substantial primary market volume of CLOs during the last ten years.[15] It furthermore conflicts with the anecdotal and empirical evidence on structured finance and market frictions.

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[12]This is to protect the SPV from the combined company's creditors. Note that the simplest way to achieve that would be to have the SPV waive its right to file voluntarily for bankruptcy. However Klee and Butler (2002) as well as other legal scholars argue that this would not be enforceable.

[13]This isolation of financial control rights is also termed as *ringfencing*.

[14]It is important to see the difference between secured debt and bankruptcy remoteness. At first it seems similar as in both cases the collateral secures a specific creditor's claim. However, there is an important difference: A secured creditor's collateral - despite being specifically attached to his claim - is still part of the combined company's bankruptcy estate and thus included into the bankruptcy procedure. So even if the secured creditor's collateral is of high quality, it is still possible that an activity of bad quality causes the company to default and the high quality collateral is included into the bankruptcy procedure. This exposes the creditor to bankruptcy costs even if his collateral was not triggering the default.

Unlike the secured creditor, a creditor to a bankruptcy remote SPV is only part of a bankruptcy procedure if the SPV defaults i.e. if the assets that specifically secure his claim cause a default. If the remaining asset of the residual company cause a default of the residual company, the assets held by the SPV are not part of the residual company's bankruptcy estate and thus the assets are not included into the bankruptcy procedure. The result is that the creditor of the SPV is in the above case not exposed to bankruptcy costs. An extended discussion of the difference between secured creditors and creditor to a bankruptcy remote SPV is found in Ayotte and Gaon (2010).

[15]The numbers in Shivdasani and Wang (2011) indicate that the issuance volume of CDO's is back to the level of 2004/05 which marked the onset of the boom of securitization. This is still only a third of the average volume during the 2005 - 2007 boom of structured finance.

3.2.2.2 Limited arbitrage and risk-induced market segmentation

A number of contributions such as Benmelech and Dlugosz (2009), Oldfield (2000) and the discussion of Gorton and Souleles (2007) attribute the evolution of structured finance to the failure of arbitrage and thus to market segmentation on the corporate bond market.[16] Modigliani and Sutch (1966) as well as Modigliani and Sutch (1967) were the first to establishment market segmentation on the sovereign bond market. They documented maturity-induced market segmentation on the sovereign bond market. On the corporate bond market, segmentation is driven by risk-induced regulation. Access to certain products of the corporate bond market often depends on an investor's profile.[17]

Risk-induced market segmentation on the corporate bond market is reenforced by comprehensive empirical evidence: Kisgen (2006) as well as Kisgen and Strahan (2010) find, that discrete costs of changes in credit ratings have a significant influence on capital structure decisions. This holds especially true at the cutoff between the investment grade and the non-investment grade market segment. Chen et al. (2010) analyse cumulative abnormal returns subsequent to a mechanical shift in bond ratings and they found a significant discontinuity at the aforementioned cutoff. Using a regression discontinuity approach, Chernenko and Sunderam (2012) find a discontinuity in availability and cost of capital at the boundary between the investment grade and the non-investment grade market segment. They find it impossible to attribute this additional friction to the non-investment grade companies' fundamentals and thus concluded that they are driven by market segmentation.

3.2.2.3 Consequences for companies

One way for a company to break exposure conservation and to mitigate market segmentation would be to access multiple market segments. This holds especially true for companies with low credit quality. Since they operate in low market segments and are thus exposed to a low level of capital supply, they have an incentive to apply techniques that allow them to access higher market segments. This is where structured finance steps in: Both techniques offer the possibility to access multiple market segments. Tranching allows a company to create a senior tranche that is issued in a high market segment, while bankruptcy remoteness allows a company to create a bond secured with low risk assets that is issued in a high market segment. This is exactly what

[16] Chen (1995) provides a nice example how market segmentation breaks arbitrage free pricing.

[17] Restrictions on market access are sometimes on the buyer's side e.g. some institutional investors are restricted or not allowed to hold non-investment grade bonds and sometimes on the seller's side e.g. certain products have selling restrictions. Miller (1986) argues that exactly these kind of access restrictions drive most of the financial innovations. See also the discussion in Benmelech and Dlugosz (2009).

is reflected in the cross section of corporate capital structures: As analyzed by Rauh and Sufi (2010), there is a substantial heterogeneity in the cross section of priority structures, with the trend that companies with low credit quality are more likely to have a tranched capital structure.

3.3 A two period model for capital structure and structured finance under market segmentation

In a related exposé[18] I proposed a two period model to capture the influence of risk-induced market segmentation on capital structure. The respective model has its basis in Leland (2007) and combines the standard capital structure trade off with a segmented market for corporate bonds in order to include the effects of market segmentation into the standard capital structure trade off. This section introduces the *generalized trade off model* developed in chapter 2 and introduces the corporate claims that are created by means of the techniques of structured finance to this model.

3.3.1 Fundamentals

3.3.1.1 Timing, environment and assets

Time in this paper is denoted by t. The model is a two period model of capital structure i.e. there are two points in time, $t = 0$ and $t = T$.

Similar to most developed corporate jurisdictions[19], companies enjoy limited liability and interest paid on corporate debt is tax deductible. The corporate tax rate is denoted by τ.

A company is in default at $t = T$ if it's liabilities exceed it's assets. Default is followed by a bankruptcy procedure that liquidates the company's assets.[20] Bankruptcy costs occur through two channels, namely the company loses a fixed amount α of its asset value and the company loses its tax shield.

Corporate assets are denoted by X_i^t where t denotes the point in time and i denotes the asset's index. Corporate assets are random cashflows that occur from business activities and they materialize at $t = T$. These random cashflows from business activities correspond to earnings before interest and taxes (EBIT) and are assumed to be $X_i^T \sim \mathcal{N}\left(\mu_{X_i}, \sigma_{X_i}\right)$ with $\mu_{X_i} \in (0, \infty)$[21]

[18] See chapter 2.
[19] See Armour et al. (2009).
[20] This corresponds to a liquidation procedure in the spirit of Title 11 United States Codes Chapter 7 (2011).
[21] The expected asset value can be decomposed into an annual net asset return r_{X_i} by solving $\mu_{X_i} = X_0\left(1 + r_{X_i}\right)^T$ where X_0 is the size of the company.

and $\sigma_{X_i} \in (0, \infty)$[22]. If there is more than one asset, the assets are assumed to be correlated with correlation coefficient $\rho_{i,j} \in [-1, 1]$. A company's taxable income are the EBIT minus a company's interest expenses.

There also exists a T-period risk-free interest rate denote by r_f^T.

3.3.1.2 Standard corporate claims and their payoffs

A corporate security's $t = T$ payoff is denoted by $\xi_k\left(X^T\right)$ while the $t = 0$ equilibrium price is denoted by q_k^*, where k denotes the index of the security. *Standard corporate claims* are a *straight bond* which is denoted by the index $k = B$, and the associated *residual equity claim* which is denoted by the index $k = E_B$. A straight bond is a security that promises a fixed amount P at $t = T$ if the company is solvent and receives everything left over, if the company is in default. The residual equity claim receives at $t = T$ the cashflows after the bond is served, if the company is solvent and is protected by limited liability, if the company is in default. The above design of the standard corporate claims combined with the environment described in section 3.3.1.1 leads to the following payoff for the straight bond

$$\xi_B\left(X^T\right) = \left\{ \begin{array}{c} P, \text{ if } X_{DB} \leq X^T \\ (1 - \tau - \alpha) X^T, \text{ if } 0 \leq X^T < X_{DB} \\ 0, \text{ if } X^T < 0 \end{array} \right\} \tag{3.1}$$

and the following payoff for the associated residual equity claim

$$\xi_{E_B}\left(X^T\right) = \left\{ \begin{array}{c} X^T - P - \tau\left(X^T - (P - q_B^*)\right), \text{ if } X_{DB} \leq X^T \\ 0, \text{ if } X^T < X_{DB} \end{array} \right\} \tag{3.2}$$

where X_{DB} denotes the default bound for the straight bond which is defined as[23]

$$X_{DB} = P + \frac{\tau}{1-\tau} q_B^* \tag{3.3}$$

[22] The asset volatility can be decomposed into an annual net asset return volatility ς_{X_i} by solving $\sigma_{X_i} = X_0 \varsigma_{X_i} \sqrt{T}$.

[23] It was assumed earlier, that a company is in default if its assets exceed its liabilities. It was further assumed that a company only pays taxes if it earns more than its interest expenses. That is to say that the default bound X_{BD} solves $0 = X^T - \tau \max\left(X^T - \left(P - q_B^*\right), 0\right) - P$ with $X^T = X_{DB}$. In the prior equation, the first term represents a company's asset value, the second term the tax expenditures and the last term the amount the company has to return to the bondholders. Note that the tax expenditures are always positive in default, otherwise the interest expenditures would exceed the bond's final fixed payment. This results in the default bound in equation 3.3.

3.3.1.3 Structured corporate claims and their payoffs

3.3.1.3.1 Tranched bond

Since there is symmetric information about asset quality, there is no role for an intermediary and it is thus assumed, that a company issues structured corporate claims by itself. A *tranched bond* is a security similar to a straight bond, only that it splits the $t = T$ promised amount into two tranches, a *senior tranche* denoted by the index $k = ST$ with promised $t = T$ amount P_{ST} and a *junior tranche* denoted by the index $k = JT$ with promised $t = T$ amount P_{JT}.[24] The total principal outstanding is then simply $P_{ST} + P_{JT}$. The equilibrium prices are denoted by q^*_{ST} and q^*_{JT} respectively. The associated *residual equity claim* is denoted by the index $k = E_T$.

As described earlier, the essence of tranching is, that the junior tranche is only served as long as the senior tranche is fully served. If the company is solvent at $t = T$, then the senior and the junior tranche both receive their promised payments while the residual equity claim receives the cashflows after the tranches are served. If the company is in default the residual equity claim is protected by limited liability, but there are two regimes to distinguish for the distribution of the liquidation proceeds to the tranches: If there are enough liquidation proceeds to serve the senior tranche, the senior tranche receives its promised payment while the junior tranche receives what is left over. If there are not enough liquidation proceeds to serve the senior tranche, the senior tranche receives everything that is left over and the junior tranche is protected by limited liability.[25] The design of the tranched bond described above leads to the following payoff for the senior tranche

$$\xi_{ST}\left(X^T\right) = \left\{ \begin{array}{c} P_{ST},\ \text{if } X_{SS} \leq X^T \\ (1-\tau-\alpha)\, X^T,\ \text{if } 0 \leq X^T < X_{SS} \\ 0,\ \text{if } X^T < 0 \end{array} \right\} \tag{3.4}$$

while the junior tranche's payoff reads

$$\xi_{JT}\left(X^T\right) = \left\{ \begin{array}{c} P_{JT},\ \text{if } X_{DT} \leq X^T \\ (1-\tau-\alpha)\, X^T - P_{ST},\ \text{if } X_{SS} \leq X^T < X_{DT} \\ 0,\ \text{if } X^T < X_{SS} \end{array} \right\} \tag{3.5}$$

and the payoff of the associated residual equity claim reads

[24] ST stands for *senior tranche,* while JT stands for *junior tranche*.
[25] For $0 < X^T$, both bonds are protected by limited liability.

$$\xi_{E_T}\left(X^T\right) = \left\{ \begin{array}{c} X^T - P_{ST} - P_{JT} - \tau\left(X^T - (P_{ST} + P_{JT} - (q^*_{ST} + q^*_{JT}))\right),\ \text{if } X_{DT} \leq X^T \\ 0,\ \text{if } X^T < X_{DT} \end{array} \right\} \tag{3.6}$$

where X_{DT} denotes the default bound of the tranched bond which is defined as[26]

$$X_{DT} = P_{ST} + P_{JT} + \frac{\tau}{1-\tau}\left(q^*_{ST} + q^*_{JT}\right) \tag{3.7}$$

and X_{SS} denotes the bound where the regime of the distribution of liquidation proceeds switches.[27] This bound is defined as[28]

$$X_{SS} = \frac{P_{ST}}{(1-\tau-\alpha)} \tag{3.8}$$

3.3.1.3.2 Bankruptcy remote bonds

Sofar the asset portfolio of a company was expressed by one single random variable X^T. The essence of bankruptcy remoteness is however piecewise financing i.e. that a company disunites itself and finances its assets separately. It is therefore necessary to impose an assumption on the elements of a company's asset portfolio: It is assumed in this paper, that a company's asset portfolio comprises two assets, *low risk assets* (LRA) and *high risk assets* (HRA), with individual asset volatilities σ_{HRA} and σ_{LRA} as well as correlation $\rho_{HRA/LRA}$. The proportions of the individual assets are set such that the company's aggregated asset volatility matches some target asset volatility.[29] If the company issues bankruptcy remote bonds, it leverages these two assets in two separate entities. These entities then issue each a straight bond denoted by the indices $k = LRB$ and $k = HRB$ with principals P_{LRB} and P_{HRB}.[30] The combined residual equity claim of these two entities is denoted by the index $k = E_R$. Since both of the separate entities

[26] The default bound X_{DT} for a tranched bond is derived in a similar fashion as the default bound in equation 3.3: X_{DT} solves $0 = X_{DT} - \tau \max\left(X_{DT} - \left(P_{ST} - q^*_{ST} + P_{JT} - q^*_{JT}\right), 0\right) - P_{ST} - P_{JT}$ for $X^T = X_{DT}$, which results in the default bound in equation 3.7.

[27] This is to say that X_{SS} is the lowest level of asset value where there are enough liquidation proceeds in default to fully serve the senior tranche. *SS* stands for *senior served.*

[28] Since X_{SS} is minimal asset value at which the senior tranche is fully served, X_{SS} solves $0 = (1-\alpha-\tau)X^T - P_{ST}$ for $X^T = X_{SS}$. This results in the bound in equation 3.8.

[29] To make this point clearer: Assume that λ_{LRA} is the proportion of low risk assets in the company's asset portfolio and that the company has an aggregated target asset volatility of $\bar{\sigma}$. (Note that since there are only two assets, the proportion of high risk assets is $\lambda_{HRA} = 1 - \lambda_{LRA}$.) Then λ_{LRA} is set such that the following relationship holds: $\bar{\sigma} = \sqrt{\lambda^2_{LRA}\sigma^2_{LRA} + (1-\lambda_{LRA})^2\sigma^2_{HRA} + 2\lambda_{LRA}(1-\lambda_{LRA})\sigma_{LRA}\sigma_{HRA}\rho_{LRA/HRA}}$.

[30] *LRB* stands for *low risk bond* while *HRB* stands for *high risk bond.*

are assumed to issue straight bonds, equation 3.1 for the bonds' payoff and equation 3.2 for the payoff of the residual equity claim as well as the default bound of equation 3.3 still apply.

3.3.2 Equilibrium capital supply for corporate claims under risk-induced market segmentation

3.3.2.1 Modelling the risk associated with a corporate bond

It is assumed in this paper that there is a form of risk-induced market segmentation observed on the corporate bond market, that creates an ordering of corporate bonds according to their risk. The model of capital structure in this paper is firm based i.e. the corporate risk policy has two elements, namely the financial risk which results from a company's leverage and the risk associated with the operational cashflows. The former element is implemented through a company's choice of total bond principal outstanding while the latter element is modelled by the distribution of X_i^T and thus primarily by σ_{X_i}. A risk measure that jointly maps both elements of the corporate risk policy implied in a corporate bond is the *annualized and discounted volatility of a bond's expected return,* which is denoted by Σ_k[31]where k denotes the index of the bond. The literature[32] generally agrees that the lower a bond's rating, the higher a bond's volatility. It is therefore consistent to model a risk ordering by means of Σ_k.

3.3.2.2 Capital supply within a market segment

The corporate bond market is assumed to be completely segmented i.e. the individual market segments do not communicate with each other. A company that implements its capital structure is now potentially new to the market segment it considers to issue a bond in. This essentially implies, that the company provides a financial innovation to the particular market segment, even though it also issues another security in a further market segment or it already has a security trading in another market segment. Financial innovations enlarge the span of the respective market segment and are not simply redundant assets. Arbitrage pricing is then disabled and an assumption on how the market supplies capital is necessary.

It is assumed that the market participants are expected utility maximizers that have a constant demand for risky securities (CDRS)[33], which is - together with the assumption of approximative normality of corporate claims - approximately equivalent to linear mean-variance

[31] A derivation of Σ_k based on a bond's volatility is given in appendix I.iii to this paper.
[32] Reilly and Wright (1997) or Reilly et al. (2009) provide illustrative and summarizing examples while Bao and Pan (2010) present a recent study.
[33] This is equivalent of assuming constant absolute risk aversion (CARA).

optimization.[34] The working assumption in this paper is therefore, that the market participants are *approximate linear mean-variance optimizers.*[35] Given the above assumption of linear mean-variance optimizers, the equilibrium capital supply schedule within a segment of the corporate bond market assuming that the market clears is given by

$$q_k^* = \mu_k - \sigma_k^2 \Gamma \tag{3.9}$$

where μ_k is a bond's discounted expected value, σ_k the discounted volatility, q_k^* the bond's equilibrium price and Γ the market segment's aggregated demand for risky securities.[36]

3.3.2.3 Equilibrium capital supply under risk-induced market segmentation

The segmentation structure of the market is drawn based on a collection of detachment points. These detachment points indicate the maximum level of Σ_k that a bond may exhibit in order to stay in a particular segment. If a bond's Σ_k surpasses a detachment point, it drops into the next lower market segment. It is assumed that the market splits in three segments, a high grade segment (HG), a mid grade segment (MG) and a non-investment grade segment (NIG). There exist thus two detachment points that indicate the boundaries between the market segments, one between the HG and the MG segment denoted by $\Sigma_{HG/MG}$ and one between the MG and the NIG segment denoted by $\Sigma_{MG/NIG}$.

The parameter Γ in equation 3.9 is the parameter, that controls the level of capital supply within a market segment. The higher Γ, the more constrained is the supply of capital and thus the more costly is capital. It is assumed that the market segments differ in terms of their levels of capital supply and i.e. that they differ in Γ. The market is assumed to split into three segments, thus there are three levels of capital supply, namely Γ_{HG} in the HG segment, Γ_{MG} in the MG segment and Γ_{NIG} in the NIG segment. In order to map the empirical evidence on market segmentation, it is assumed that we have $\Gamma_{HG} < \Gamma_{MG} < \Gamma_{NIG}$ i.e. capital supply is more constrained in lower market segments.

These two elements of market segmentation, namely the levels of capital supply within market

[34] This is analytically derived in Collins and Gbur (1991). Tsiang (1972) as well as Hanson and Ladd (1991) illustrate this numerically.

[35] The assumption of a mean-variance market for corporate capital appears frequently in the literature on corporate finance with frictions such as in Rubinstein (1973a), Rubinstein (1973b), Glenn (1976) or Kim (1978). The mean-variance model also remains a widely used market model in practice on both ends of the market as investigated by Graham and Harvey (2001) as well as Fabozzi et al. (2002).

[36] This equation corresponds to equation 2.10 in chapter 2. Equations for μ_k and σ_k for the different corporate claims in this paper are given in appendix I. For a derivation of this equation using the market clearing argument I refer the reader to the aforementioned exposé.

segments and the detachment points, construct the risk-induced market segmentation on the corporate bond market. It is implemented through a *segmentation function* $\psi : \Sigma_B \rightarrow \Gamma$ that maps the risk level Σ_k of a given bond on its respective level of capital supply Γ. The function is defined piecewise and reads

$$\psi\left(\Sigma_k; \mathbf{\Sigma}, \mathbf{\Gamma}\right) = \left\{ \begin{array}{c} \Gamma_{\mathrm{HG}}, \ \text{if} \ \Sigma_{\mathrm{k}} < \Sigma_{\mathrm{HG/MG}} \\ \Gamma_{\mathrm{MG}}, \ \text{if} \ \Sigma_{\mathrm{HG/MG}} < \Sigma_{\mathrm{k}} < \Sigma_{\mathrm{MG/NIG}} \\ \Gamma_{\mathrm{NIG}}, \ \text{if} \ \Sigma_{\mathrm{MG/NIG}} < \Sigma_{\mathrm{k}} \end{array} \right\} \tag{3.10}$$

with $\mathbf{\Sigma} = \left(\Sigma_{\mathrm{HG/MG}}, \Sigma_{\mathrm{MG/NIG}}\right)$ and $\mathbf{\Gamma} = \left(\Gamma_{\mathrm{HG}}, \Gamma_{\mathrm{MG}}, \Gamma_{\mathrm{NIG}}\right)$.[37]

The segmentation function of equation 3.10 determines to what segment and thus to what level of capital supply a bond is assigned. Given the mechanism that determines the level of capital supply a bond is exposed to, a bond's equilibrium price under complete market segmentation reads

$$q^* = \mu_k - \sigma_k^2 \psi\left(\Sigma_k; \mathbf{\Sigma}, \mathbf{\Gamma}\right) \tag{3.11}$$

Equations for μ_k and σ_k for the different corporate claims are given in appendix I to this paper.

Note that tranching and bankruptcy remoteness are only effective if they allow a company to operate in multiple market segments. This is what breaks exposure conservation. The tranched bond introduced in section 3.3.1.3.1 only breaks exposure conservation, if the senior tranche is issued in another market segment than the junior tranche. The bankruptcy remote bonds introduced in section 3.3.1.3.2 only break exposure conservation, if the bond secured with low risk assets is issued in another market segment than the bond secured with high risk assets. If this is not the case, then structured finance is neutral as in a frictionless market. This is because the level of capital supply differs between market segments while within a market segment all securities are exposed to the same friction. If the company cannot spread it's bonds across the market segments then tranching and bankruptcy remoteness have no effect and the company is then not better off as the company would be, if it is using a straight bond. Because of this it is assumed, that companies only apply structured finance, if the techniques have the power to break exposure conservation.

[37] The above equation corresponds to equation 2.12 in chapter 2.

3.3.3 Optimal capital structure

Companies in this paper are operated by an owner manager that has risk neutral utility and holds the residual equity claim.[38] At $t = 0$ a company has its assets in place, but the owner manager has not taken a decision on the company's capital structure. If bonds are issued, the market value of the bonds is determined by equation 3.11[39]. The owner manager chooses the capital structure such that it maximizes the company's value. If he issues a straight bond, then the bond's optimal principal P^* is such that

$$P^* = \arg\max_{P} \left\{ q_B^* + \mu_{E_B} \right\} \tag{3.12}$$

If the company issues a tranched bond then the optimal principals of the tranches of the tranched bond P_{ST}^* and P_{JT}^* are such that

$$\left\{ P_{ST}^*, P_{JT}^* \right\} = \arg\max_{P_{ST}, P_{JT}} \left\{ q_{ST}^* + q_{JT}^* + \mu_{E_T} \right\} \tag{3.13}$$

If the company issues bankruptcy remote bonds then the optimal principals of the bond secured with low risk assets and the bond secured with high risk assets P_{LRB}^* and P_{HRB}^* are such that

$$\left\{ P_{LRB}^*, P_{HRB}^* \right\} = \arg\max_{P_{LRB}, P_{HRB}} \left\{ q_{LRB}^* + q_{HRB}^* + \mu_{E_R} \right\} \tag{3.14}$$

Equation 3.12 is the generalized trade off model that is derived in chapter 2. This approach to optimal capital structure accounts for the tax shield and bankruptcy costs, but additionally for limited capital supply caused by risk-induced market segmentation. Equations 3.13 and 3.14 present an augmentation to the generalized trade off model, that allows to apply and analyze the effects of the techniques of structured finance under risk-induced market segmentation. The applications are presented in the following section.

[38]This implies that the owner manager values the equity stake at its expected value i.e. by means of equation 3.19 or 3.24 in appendix I to this paper. The owner manager is constrained to hold solely the residual equity claim in order to avoid arbitrage opportunities. Note that capital and borrowing constrains to an owner manager are common and thus a reasonable assumption.

[39]The owner manager measures a bond's value in terms of the proceeds the company receives, when it issues a bond. This implies that the owner manager prices a bond at the market's willingness to pay, which is equivalent to a bond's equilibrium price q_k^*.

3.4 Structured finance under market segmentation: Applications

3.4.1 Parameters

In this part, the model to analyze structured finance under market segmentation laid out in section 3.3, is applied. Note that the tax shield creates a cross dependency between the payoff and the market value of a bond i.e. ξ_k implicitly depends on q_k. Because of this there is no explicit solution to the model and it is instead relied on numerical techniques.

Table 3.1 reports the choice of parameters that are fixed throughout the paper unless mentioned otherwise. The parameters are equivalent to the choice in chapter 2: The bankruptcy costs α are such that they match observed recovery rates in two period models, the tax rate τ is a literature average for the effective tax rate, time to maturity T is the median debt maturity of corporate bonds, the risk-free rate per annum r_f is the ten year median of the constant maturity treasury rate corresponding to T and the size of the company is set to $X_0 = 100$.

INSERT TABLE 3.1 ABOUT HERE

Since most of the bond valuation models applied in empirical studies assume a frictionless market and use risk-neutral pricing, the expected returns of corporate assets are generally not observed. Returns on commodities or returns on real estate are potential proxies and exhibit steady long term returns of about 10%.[40] The expected return on corporate assets is assumed to be equivalent over all market segments and variations in asset quality are modelled through variations in asset volatility.

Annual asset volatilities are chosen according to Schaefer and Strebulaev (2008). I consider a AAA rated company as a representative company of the HG segment, a BBB rated company as a representative company of the MG segment and a B rated company as a representative company of the NIG segment. The detachment points are chosen according to the empirical study on the bond market conducted by Reilly and Wright (1997). Their estimates lie in the same order of magnitude as Bao and Pan (2010).[41]

The parameters for the aggregated supply of capital to the MG segment Γ_{MG}, is set such, that the optimal bond matches the average observed leverage ratio of a BBB rated company as

[40] The FTSE NAREIT real estate indices exhibit steady long term annual returns of 10% (Source: http://returns.reit.com/returns/DomesticReturns.pdf, Accessed July 08, 2011.). The numbers in Greer (2000) on long term returns on commodity indices are in the same order of magnitude.

[41] For a detailed discussion on the choice of the asset volatilities and the detachment points I refer the reader to the discussion in chapter 2 in section 2.3.4.1.

indicated by Schaefer and Strebulaev (2008). In the HG segment, the capital supply parameter Γ_{HG} is low - only half its MG value - in order to model the high supply to this market segment and in order to be close to the standard trade off model. In the NIG segment, the capital supply parameter Γ_{NIG} has double its MG value in order to model the regulatory and risk-induced capital constraints in the NIG segment.[42]

As it was noted earlier, for companies that use bankruptcy remote bonds an additional assumption is necessary, namely regarding their asset portfolio. It is assumed that there exists two kinds of assets, low risk assets and high risk assets with either a low or a high asset volatility. Table 3.2 reports the asset volatilities for the individual assets and their correlation. The asset volatilities correspond to the asset volatilities of a representative HG and NIG company respectively. Correlation is set to an average value in order to avoid underdiversification.

INSERT TABLE 3.2 ABOUT HERE

3.4.2 How a company forms its capital structure

3.4.2.1 Tranched bond

Figures 3.1 to 3.8 provide numerical applications of the model laid out in section 3.3. Figures 3.1 and 3.2 illustrate the capital structure trade off of a company with a tranched bond and equity in a segmented corporate bond market using equation 3.13 and the parameters of table 3.1.

Figure 3.1 presents the capital structure trade off of a company with the asset volatility of a BBB rated company i.e. a company of the MG segment. The first panel of figure 3.1 presents the total company value as a function of the leverage ratio for a company with a tranched bond - this is the solid black line - versus a lower and an upper benchmark. The upper benchmark is the total company value of a company with the same assets in a frictionless market - this is the grey dashed line - while the lower benchmark is the total company value of the same company in a segmented corporate bond market - this is the dashed black line - both with a standard straight bond outstanding . The second panel of figure 3.1 illustrate the levels of capital supply[43] that are assigned to the bonds in a segmented corporate bond market, where the solid black line is the level of capital supply assigned to the senior tranche, the dashed black line the level of capital supply assigned to the junior tranche and the gray dashed line is the level of capital supply assigned to the bond of a company using a straight bond. The third panel of figure 3.1

[42]In chapter 2 a detailed discussion on the choice for the parameters of aggregated capital supply is provided with reference to the literature on asset pricing, insurance and production theory.

[43]The level of capital supply of a bond corresponds to the Γ that is assigned to a particular bond through $\psi\,(\,.\,)$.

illustrates the share of total principal outstanding that is promised to the senior tranche. The fourth panel of figure 3.1 illustrates the value added unlocked through tranching as a percentage of total company value. The scales on the x-axis of the individual panels of figure 3.1 match each other. This applies to all illustrations in appendix III to this paper.

INSERT FIGURE 3.1 ABOUT HERE

Without tranching, a company with the asset volatility of a BBB rated company exhibits a sharp kink in company value visible in the first panel of figure 3.1. The kink occurs at the point where the company's bond drops from the MG to the NIG segment at about a leverage ratio of 0.335. As a result of this kink, the company's optimal capital structure is a corner solution.

As it is evident from the first and fourth panel of figure 3.1, tranching helps to mitigate this effect of market segmentation: With a tranched bond the company issues the senior tranche in either the HG or the MG market segment while the junior tranche is issued in the NIG segment. The kink in company value goes then almost unnoticed and is moved up to a leverage ratio of approximately 0.3475, which is where the senior tranche drops from the HG to the MG segment. The additional value unlocked through tranching illustrated in the fourth panel is strictly positive.

But despite the application of tranching, there remain some effects from market segmentation: As it becomes evident from the third panel of figure 3.1, if the senior tranche is close to the bound between the segments, the company reduces the principal of the senior tranche relative to the junior tranche in order to preserve the level of capital supply of the senior tranche. This implies that despite tranching, some effects of market segmentation remain. This is consistent with what is argued in Oldfield (2000), namely that tranching constitutes an imperfect mechanism to mitigate market segmentation.

Figure 3.2 presents illustrations equivalent in structure to figure 3.1 for a company with the asset volatility of a B rated company i.e. a company of the NIG segment. Without tranching, the company is not subject to a kink, as the company's asset quality is low and the company would have to restrict is leverage too much in order to stay in higher market segments.

INSERT FIGURE 3.2 ABOUT HERE

With tranching however, the company may still mitigate part of the effects of market segmentation by issuing the senior tranche in the MG segment and only the junior tranche in the NIG segment. This allows the company to unlock additional value and to increase its optimal leverage from around 0.23 to 0.27. At this point the magic ends: It is no longer possible for the company to issue the senior tranche in the MG segment and thus tranching becomes obsolete.

3.4.2.2 Bankruptcy remote bond

Figures 3.3 and 3.4 illustrate the capital structure trade off of a company that applies bankruptcy remoteness in a segmented corporate bond market using equation 3.14 and the parameters of tables 3.1 and 3.2, in a similar fashion as figures 3.1 and 3.2.

As mentioned earlier, with bankruptcy remoteness the company disunites itself. The company's overall asset volatility in figure 3.3 is the asset volatility of a BBB rated company i.e. a company of the MG segment similar to figure 3.1. The company has low risk assets and high risk assets in its asset portfolio with volatilities and correlation as reported in table 3.2. Applying the equation of footnote 29, this results in a proportion of low risk assets of approximately 19%. With bankruptcy remoteness the company uses these two asset classes separately to issue two bankruptcy remote bonds.

INSERT FIGURE 3.3 ABOUT HERE

The second panel of figure 3.3 illustrate the levels of capital supply assigned to the bonds: The black solid line depicts the level of capital supply assigned to the bond secured with low risk assets, the black dashed line depicts the level of capital supply assigned to the bond secured with high risk assets, while the grey dashed line depicts the level of capital supply assigned to the bond of a company that does not apply bankruptcy remoteness.

The bond secured with low risk assets is always assigned to the HG segment while the bond secured with high risk assets is always assigned to the NIG segment. As illustrated by the third panel, the company is actively maintaining this structure as it slowly decreases the share of total principal outstanding promised to the bond secured with low risk assets as the share of low risk assets decreases.

The first and the fourth panel of figure 3.3 illustrate the effect on total company value. As it is illustrated in the first panel, the optimal leverage is actually lower with bankruptcy remoteness than without this technique. Moreover, the value added is not strictly positive under bankruptcy remoteness and it is especially negative at the point of optimal leverage without bankruptcy remoteness. Bankruptcy remoteness is therefore a technique not suited for companies of the MG segment as an MG company does not need to establish access to investment grade funding.

Figure 3.4 presents illustrations equivalent to figure 3.3 for a company with the overall asset volatility of a B rated company. Given the parameters in table 3.2, this results in a proportion of low risk assets of approximately 4%. Similar to figure 3.3, the company uses the low risk assets to create a bond that is issued in the HG segment, while the remaining debt is secured with high risk assets and is issued in the NIG segment. This is illustrated in the second panel. As depicted in the fourth panel, the additional value unlocked is strictly positive over the entire grid and increases with increasing leverage for a company with the overall asset volatility of a B rated company.

INSERT FIGURE 3.4 ABOUT HERE

Figure 3.3 and 3.4 illustrate that bankruptcy remoteness may be a tool to mitigate the effects of market segmentation, but not for all companies but only for companies with a high overall asset volatility. This is because for companies of the HG and MG segment that already have access to high market segments, the decrease in value through the bond that is secured purely with high risk assets is not offset by the increase in value through the bond that is secured purely with low risk assets.

For a company of the NIG segment that would issued a bond in the NIG segment without bankruptcy remoteness, the increase in value offsets the decrease. This is consistent with Schwarcz (1994) where it is argued that bankruptcy remoteness is a tool to access higher market segment.

3.4.3 Optimal capital structure

3.4.3.1 Tranched bond

Figure 3.5 presents the path of total company value with optimal leverage of a company that applies tranching. The first panel of figure 3.5 presents the actual path, where the solid black line is the path of total company value for a company in a segmented bond market, that applies tranching, the dashed black line is the path of total company value for a company in a segmented bond market, that does not apply tranching and the path of total company value for a company in a frictionless market is depicted by the grey dashed line. The second panel depicts the levels of capital supply, where the solid black line depicts the level of capital supply assigned to the optimal senior tranche, the dashed black line the level of capital supply assigned to the optimal junior tranche and the dashed gray line the level of capital supply assigned to the optimal bond of a company, that does not apply tranching. The third panel illustrates the fraction of total principal outstanding, that the company that applies tranching optimally promises to the senior tranche, while the fourth panel illustrates the additional value unlocked through tranching.

INSERT FIGURE 3.5 ABOUT HERE

As depicted in the first panel for figure 3.5, the total company value is strictly higher, if a company applies tranching. The path of the company that applies tranching has a kink at the point, where the senior tranche changes from the HG to the MG segment. As depicted in the third panel, a company that has an asset volatility close to the kink has an incentive to locally constrain the fraction of relative principal outstanding assigned to the senior tranche in order to keep the senior tranche in the HG segment. A similar incentive is active, if the company has a very high asset volatility, in this case the company reduces the relative fraction of the senior tranche in order to keep the senior tranche in the MG segment.

The graph of value unlocked through tranching in the fourth panel has a few interesting kinks and turning points: The first kink occurs, where the optimal bond of a company without tranching changes from the HG to the NIG segment. Prior to this kink there is a short range of steep increase. This is because prior to the segmentation bound, the company without tranching has an incentive to constrain its leverage in order to keep its straight bond in the HG segment. There is a downward kink at about an asset volatility of 0.235, which occurs at the point, where the senior tranche changes the segment. After that there is another range of steep increase in value unlocked, which occurs, because the company that does not apply tranching constrains its leverage in order to keep its straight bond in the MG segment. The turning point occurs at the point, where the company that does not apply tranching changes to the NIG segment. At the end the value unlocked by tranching remains positive, but decreases with asset volatility.

The general trend of the graph in the fourth panel of figure 3.5, that the value unlocked through tranching is higher for companies with high annual asset volatility, is consistent with the empirical evidence in both Maskara (2010) and Rauh and Sufi (2010). The evidence in Maskara (2010) suggests, that borrowers with low credit quality are more likely to issue tranched bonds and that the benefits of tranching accrue primarily to borrowers with low credit quality. Also the stylized facts in Rauh and Sufi (2010) suggests, that borrowers with low credit quality are more likely to have a capital structure with multiple debt layers. The results in the fourth panel of figure 3.5 provide an economic rationale for these empirical findings.

Figure 3.6 illustrates the equilibrium paths of optimal leverage. The first panel of figure 3.6 depicts the paths of optimal leverage given the level of annual asset volatility. The solid black line illustrates the optimal leverage path of a company that applies tranching, the dashed black line the path of a company, that does not apply tranching and the dashed grey line the path of a company in a frictionless market. The second panel of figure 3.6 depicts the levels of capital supply equivalent to the second panel of figure 3.5. The third panel depicts the difference in optimal leverage between a company that applies tranching and a company that does not apply tranching. The fourth panel of figure 3.6 depicts the annual volatilities of the optimal tranches of a tranched bond and the annual volatility of the optimal bond of a company, that does not apply tranching. The dashed black line depicts the annual volatility of the optimal senior tranche, the solid black line depicts the annual volatility of the optimal junior tranche and the dashed gray line depicts the annual volatility of the optimal bond of a company that does not apply tranching.

INSERT FIGURE 3.6 ABOUT HERE

As depicted in the first and the third panel of figure 3.6, a company that applies tranching has higher optimal leverage than a company that does not apply tranching. Tranching is therefore a technique to mitigate market segmentation.

But as already recognized in section 3.4.2.1, it is not a perfect technique. A company that applies tranching is still subject to some effects of market segmentation: Prior to the level of asset volatility where the senior tranche drops to the MG segment, there is an area where leverage decreases steeply because the company rations its overall leverage in order to preserve the level of capital supply of the senior tranche. After the senior tranche has dropped to the MG segment, overall leverage recovers somewhat, but again falls steeply at a leverage ratio of approximately 0.25 in order to preserve the level of capital supply of the senior tranche. The drop of the junior tranche from the MG to the NIG segment however, goes almost unnoticed.

This discussion is emphasized by the fourth panel of figure 3.6. Remember that market segmentation is risk-induced, based on a collection of volatility detachment points. When the volatility of an optimal tranche or optimal bond is close to a detachment point, a company has - with and without tranching - an incentive to reduce the principal of the respective tranche or bond in order to preserve the level of capital supply of the respective tranche or bond.

This is exactly what happens in the first and fourth panel of figure 3.6: The annual volatility of the senior tranche is rising with the asset volatility. However, a company close to the segmentation bound reduces the principal of the senior tranche in order to keep the senior tranche's annual volatility below the HG/MG detachment point. This perserves the segment assignement of the senior tranche to the HG segment and it is what creates the first flat part of the respective graph. Towards the higher end of the asset volatility scale this effect is repeated: A company is again reducing the principal of the senior tranche in order to preserve the senior tranche's assignement - this time to the MG segment.

The graph of the annual volatility of the junior tranche is flat at the beginning in order to keep the senior and the junior tranche in separate segments. After this flat part the annual volatility of the junior tranche is gradually increased until the area, where companies have an incentive to preserve the annual volatility of the senior tranche. In this area the volatility of the junior tranche is steeply increased until the senior tranche drops to the MG segment. After the senior tranche has changed the segment, the volatility of the junior tranche again gradually increases followed by a subsequent decline. The decline is the result of a gradual decrease in overall leverage.

The incentive to constrain leverage in order to preserve the level of capital supply of a tranche or bond holds for companies with and without tranching if they are close to the segmentation bounds. This was already discussed in chapter 2 and leads to apparently underleverage companies.

But as depicted in the third panel of figure 3.6, these incentives to constrain leverage induced by market segmentation are weakened through tranching. Tranching mitigates these leverage constrains especially well for a company that is around the bound to the NIG segment. This is consistent with the empirical evidence in Benmelech and Dlugosz (2009) - especially figure 5 of the respective paper - which shows that the collaterals in CLOs issued in the period $2000 - 2007$ are similarly concentrated around the boundary between the MG and the NIG segment.

The observation of higher optimal leverage for companies that apply tranching implies, that these companies enjoy lower costs of funding. This is exactly what is implied by the empirical evidence in Nadauld and Weisbach (2012), namely that structured finance implies lower rates of funding for the applying companies. The respective paper leaves the question open what the sources of these observations were and whether it is rational. The model in this paper rationalizes this finding, arguing that structured finance partly mitigates risk-induced market segmentation.

3.4.3.2 Bankruptcy remote bonds

Figure 3.7 presents the equilibrium path of total company value with optimal leverage of a company that applies bankruptcy remoteness. The first panel of figure 3.7 presents the actual path, where the solid black line is the path of total company value for a company in a segmented bond market that applies bankruptcy remoteness, the black dashed line is the path of total company value for a company in a segmented bond market that does not apply bankruptcy remoteness, while the path of total company value for a company in a frictionless market is depicted by the grey dashed line. The second panel depicts the levels of capital supply, where the solid black line depicts the level of capital supply of the bond secured with low risk assets, the dashed black line the level of capital supply of the bond secured with high risk assets and the dashed gray line the level of capital supply of the optimal bond of a company that does not apply bankruptcy remoteness. The third panel depicts the relative fraction of low risk assets in the company's asset portfolio given the annual overall target asset volatility on the x-axis and the figures from table 3.2. The fourth panel depicts the relative fraction of overall principal outstanding that is promised to the bond secured with low risk assets. The dashed black line in the fifth panel depicts the value added unlocked through bankruptcy remoteness, while the gray dashed line in the same panel indicates zero.

INSERT FIGURE 3.7 ABOUT HERE

What stands out at first is that the separation of assets through bankruptcy remoteness cleans up the discontinuities in the equilibrium path of total company value. This is because over the grid of annual overall asset volatility, it is the proportion of low risk assets in the company's asset portfolio that varies, but not the risk of the components of that portfolio i.e. of the low risk and high risk assets. This implies that the mitigation of the discontinuities is conditional on the assumption, that companies have heterogenous asset portfolios. If this is not the case i.e. if a company with a high overall annual asset volatility has a homogenous asset portfolio, bankruptcy remoteness would obviously be a neutral technique.

The first and the fifth panel of figure 3.7 reveal, that bankruptcy remoteness does not unlock positive value added for all companies, but only for companies with high asset volatility. Only in the area, where the annual overall asset volatility is high enough such that a company that does not apply bankruptcy remoteness either rations its leverage in order to preserve its optimal bond's level of capital supply or is already issuing its bond in the NIG segment, only there has bankruptcy remoteness the power to unlock additional value.

This is consistent with what is suggested by Schwarcz (1994), namely that for a company with a heterogenous asset portfolio, bankruptcy remoteness is a technique to access higher market segments by exploiting their high quality assets. It is further consistent with the empirical evidence in Ayotte and Gaon (2010). In that paper the authors show that bankruptcy remoteness is an explanatory factor for funding rates.

Figure 3.8 illustrates the equilibrium path of optimal leverage for a company that applies bankruptcy remoteness. The first panel depicts the equilibrium paths, where the solid black line is the equilibrium path of a company that applies bankruptcy remoteness, the dashed black line the equilibrium path of a company that does not apply bankruptcy remoteness and the dashed grey line is the equilibrium path of a company in a frictionless market. The second, the third and the fourth panel in figure 3.8 are equivalent to the second, the third and the fourth panel in figure 3.7 and depict the levels of capital supply of the bonds, the proportion of low risk assets in the company's asset portfolio and the relative fraction of overall principal outstanding, that is promised to the bond secured with low risk assets. The fifth panel depicts the additional leverage unlocked through to the application of bankruptcy remoteness. The dashed black graph illustrates the actual difference, while the solid black spike indicates the zero.

INSERT FIGURE 3.8 ABOUT HERE

The situation with respect to optimal leverage is similar to figure 3.7: Leveraging the assets separately allows a company with a heterogenous asset portfolio to mitigate potential kinks in the equilibrium path of optimal leverage. This implies that it mitigates market segmentation as well as the potential incentive to constrain leverage in order to preserve the level of capital supply.

The application of bankruptcy remoteness unlocks additional leverage capacity for a company that would otherwise constrain its leverage in order to preserve its level of capital supply or for companies that would otherwise have to issue their optimal bond in the NIG segment. This again emphasizes what is argued in Schwarcz (1994) and Ayotte and Gaon (2010), that bankruptcy remoteness is an explanatory factor for the funding rates of companies that engage in securitization.

3.5 Structured finance and the late-2000s financial crisis: A case for CLOs

In the above section it was shown that if a form of risk-induced market segmentation prevails on the corporate bond market, then the primary techniques of structured finance, namely tranching and bankruptcy remoteness, allow a company to improve its capital structure and adjust it more accurately to the segmented bond market. It was further shown that this improvement implies, that a company may increase its value, but also decreases its cost of capital and thus increases its optimal leverage.

This is anecdotally consistent with what is argued in Shivdasani and Wang (2011) as well as in Nadauld and Weisbach (2012). They argue that the boom of structured finance prior to the late-2000s financial crisis fueled a wave of corporate lending through CLOs. However, structured finance was often mentioned as a trigger for the late-2000s financial crisis. Because of this it shall be surveyed in the following, whether structured lending and especially corporate lending through CLOs had a causal effect on the crisis and how the CLOs performed subsequently.

The literature generally agrees, that during the years prior to the crisis there was a decline in credit quality and thus an overinvestment into the subprime segment of RRE CDOs.[44] This evolution was revealed through the construction of the ABX.HE index, an index for subprime RRE CDOs.[45]

However, there is less agreement on whether there was a similar overinvestment into other segments of the market for structured securities. The evidence in the CDX[46] market is mixed: Coval et al. (2009) suggested that the senior CDX tranches were misspriced prior to the crisis, while Collin-Dufresne et al. (2010) takes the opposite position. Nadauld and Weisbach (2012) conclude that the application of structured finance implied lower rates of funding but leave the question open whether this was rational or not. The empirical evidence in Shivdasani and Wang (2011) as well as in Benmelech et al. (2012) finds no evidence for the argument that CLO lending led to a decline in credit quality similar as in subprime RRE CDO lending. This is reenforced by the evidence in Benmelech and Dlugosz (2009), which presents that, although there were downgrades of mezzanine tranches of CLOs, they were far less severe than the downgrades on mortgage related CDOs and that there were hardly downgrades of senior CLO tranches.

The above empirical evidence suggests that CLO lending was - as opposed to subprime RRE CDO lending - not a channel of overlending and thus overinvestment. However, the rationale of this high CLO lending prior to the crisis is still disputed. The rationale that this paper provides is, that structured finance allows companies to adjust their capital structure more accurately to the segmented bond market. This leads to additional lending with corresponding value creation. This stands in contrast to subprime lending, which was to some part clearly an overinvestment. Thus structured finance for corporation should - despite the financial crisis - be seen as an important tool to adjust corporate capital structures to segmented markets rather than the trigger of the financial crisis.

[44]See for example Demyanyk and Van Hemert (2011) for an empirical study.
[45]See Gorton (2009) for a comprehensive analysis of this story.
[46]CDX is a family of indices of corporate credit default swaps offered by Markit.

3.6 Conclusion

Despite the substantial volume of corporate capital market instruments involving the techniques of structured finance, the techniques of structured finance have not been understood well. Without proposing an economic foundation, some contributions have put forward segmentation in funding market as a rationale for structured finance.

This paper contributes to the literature on capital structure and structured finance by providing an economic foundation for the argument, that segmentation in the corporate funding market is the driver for the application of the techniques of structured finance. In a generalized trade off model for capital structure that incorporates a segmented corporate bond market, it is shown how the application of tranching and bankruptcy remoteness improve a corporate capital structure.

Specifically, tranching allows a company to adjust its capital structure more accurately to the segmented funding market as it allows the company to access multiple market segments. Although tranching reduces the impact of market segmentation, tranching is only an imperfect mechanism to mitigate market segmentation, as the tranches remain subject to market segmentation. If a tranche of a tranched bond is close to a segmentation bound, the company is still exposed to potential discontinuities in the capital structure trade off. Through the improvement of the capital structure, tranching allows companies to unlock additional value and reduce its cost of capital. This in turn allows for higher optimal leverage. Tranching improves the capital structure for all corporate risk levels, but consistent with empirical evidence, it is particularly powerful for low credit quality companies.

Bankruptcy remoteness also allows a company to adjust its capital structure more accurately to the segmented funding market as it allows the company to concentrate its collaterals according to quality. This is consistent with empirical evidence that documents, that bankruptcy remoteness is an explanatory factor for cost of capital. However, bankruptcy remoteness only unlocks additional value for companies with low credit quality, that would not have access to higher market segments, if they simply rely on a straight bond. For companies that already have access to high market segments, bankruptcy remoteness is not value creating within the context of a segmented funding market. In the area where bankruptcy remoteness is value creating, it also reduces the companies cost of capital and thus implies higher optimal leverage. It is particularly powerful at the boundary between investment grade and non-investment grade funding i.e. between the MG and the NIG segment. This is the area, where a company would - without bankruptcy remoteness - have an incentive to constrain its leverage in order to maintain its level of capital supply.

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Appendix

I Moments for corporate securities

Let $X \sim \mathcal{N}(\mu_X, \sigma_X)$. Denote the associated density function by $\phi(x; \mu_X, \sigma_X)$ and the associated cumulative distribution function by $\Phi(x; \mu_X, \sigma_X)$. The standard normal density function and distribution function are denoted by $\phi(x)$ and $\Phi(x)$. The following definitions follow from Winkler et al. (1972) equation 2.6 and the subsequent lines on page 292:

$$G(a, b, \mu_X, \sigma_X) \equiv \int_a^b x\phi(x; \mu, \sigma)\, dx = \mu_X \left(\Phi\left(\frac{b-\mu_X}{\sigma_X}\right) - \Phi\left(\frac{a-\mu_X}{\sigma_X}\right)\right) - \sigma_X \left(\phi\left(\frac{b-\mu_X}{\sigma_X}\right) - \phi\left(\frac{a-\mu_X}{\sigma_X}\right)\right) \tag{3.15}$$

$$V(a, b, \mu_X, \sigma_X) \equiv \int_a^b x^2\phi(x; \mu, \sigma)\, dx = \left(\mu_X^2 + \sigma_X^2\right)\left(\Phi\left(\frac{b-\mu_X}{\sigma_X}\right) - \Phi\left(\frac{a-\mu_X}{\sigma_X}\right)\right) + \sigma_X(\mu_X + a)\,\phi\left(\frac{a-\mu_X}{\sigma_X}\right) - \sigma_X(\mu_X + b)\,\phi\left(\frac{b-\mu_X}{\sigma_X}\right) \tag{3.16}$$

i Straight bond and equity

The moments for a T-period straight bond and the associated residual equity claim with payoffs as in equations 3.1 and 3.2, are derived in chapter 2, equations 2.18, 2.21 and 2.22. The expected value of the straight bond reads

$$\mu_B = \left(\frac{1}{1+r_f^T}\right)\left((1-\tau-\alpha)\, G(0, X_{DB}, \mu_X, \sigma_X) + P\,(1 - \Phi(X_{DB}; \mu_X, \sigma_X))\right) \tag{3.17}$$

the volatility of the straight bond reads

$$\sigma_B^2 = \left(\frac{1}{1+r_f^T}\right)^2 \left((1-\tau-\alpha)^2 V(0, X_{DB}, \mu_X, \sigma_X) + P^2\,(1 - \Phi(X_{DB}; \mu_X, \sigma_X)) - \mu_B^2\right) \tag{3.18}$$

and the expected value of the residual equity claim reads

$$\mu_{E_B} = \left(\frac{1}{1+r_f^T}\right)\left((1-\tau)G(X_{DB}, \infty, \mu_X, \sigma_X) + \left((\tau-1)\,P - \tau q_B^*\right)(1 - \Phi(X_{DB}; \mu_X, \sigma_X))\right) \tag{3.19}$$

where $G(\,.\,)$ is defined as in equation 3.15, $V(\,.\,)$ as in equation 3.16 and X_{DB} as in equation 3.3.

ii Tranched bond and equity

a Senior tranche

The payoff of a T-period senior tranche is given by equation 3.4. This payoff is equivalent to the payoff of a straight bond only that X_{DB} is exchanged for the bound, where the senior tranche is served X_{SS}. By relying on equations 3.17 and 3.18 the expected discounted value of the senior tranche reads

$$\mu_{ST} = \left(\frac{1}{1+r_f^T}\right)\left((1-\tau-\alpha)\,G\left(0, X_{SS}, \mu_X, \sigma_X\right) + P_{ST}\left(1-\Phi\left(X_{SS}; \mu_X, \sigma_X\right)\right)\right) \tag{3.20}$$

while the expected discounted variance reads

$$\sigma_{ST}^2 = \left(\frac{1}{1+r_f^T}\right)^2 \left((1-\tau-\alpha)^2 V\left(0, X_{SS}, \mu_X, \sigma_X\right) + P_{ST}^2\left(1-\Phi\left(X_{SS}; \mu_X, \sigma_X\right)\right) - \mu_{ST}^2\right) \tag{3.21}$$

where X_{SS} is defined as in equation 3.8.

b Junior tranche

The payoff of a T-period junior tranche is given by equation 3.5. The expected discounted value of the junior tranche is then given by

$$\mu_{JT} = \left(\frac{1}{1+r_f^T}\right)\mathbb{E}\left[\xi_{JT}(X)\right] = \left(\frac{1}{1+r_f^T}\right)(1-\tau-\alpha)\int_{X_{SS}}^{X_{DT}} x\phi\left(x; \mu_X, \sigma_X\right)dx$$

$$\left(\frac{1}{1+r_f^T}\right)\left(-\int_{X_{SS}}^{X_{DT}} P_{ST}\phi\left(x; \mu_X, \sigma_X\right)dx + \int_{X_{DT}}^{\infty} P_{JT}\phi\left(x; \mu_X, \sigma_X\right)dx\right)$$

Applying equation 3.15 yields

$$\mu_{JT} = \left(\frac{1}{1+r_f^T}\right)\left((1-\tau-\alpha)G\left(X_{SS}, X_{DT}, \mu_X, \sigma_X\right)\right)$$

$$-P_{ST}\left(\Phi\left(X_{DT}, \mu_X, \sigma_X\right) - \Phi\left(X_{SS}, \mu_X, \sigma_X\right)\right) + \left(\frac{1}{1+r_f^T}\right)\left(1-\Phi\left(X_{DT}, \mu_X, \sigma_X\right)\right) \tag{3.22}$$

The junior tranche's discounted variance is given by

$$\sigma_{JT} = \left(\frac{1}{1+r_f^T}\right)^2 \left(\mathbb{E}\left[(\xi_{JT}(X))^2\right] - (\mathbb{E}[\xi_{JT}(X)])^2\right) = \left(\frac{1}{1+r_f^T}\right)^2 \left(\mathbb{E}\left[(\xi_{JT}(X))^2\right] - \mu_{JT}^2\right)$$

All terms of the above difference are known except for the first one. Applying the definition of the expected value operator yields

$$\mathbb{E}\left[(\xi_{JT}(X))^2\right] = \int_{X_{SS}}^{X_{DT}} \left((1-\tau-\alpha)^2 x^2 - 2(1-\tau-\alpha)xP_{ST} + P_{ST}^2\right) \phi(x;\mu_X,\sigma_X)\,dx$$

$$+P_{JT}^2 \int_{X_{DT}}^{\infty} \phi(x;\mu_X,\sigma_X)\,dx$$

Using equations 3.15 as well as 3.16 and relying on the above auxiliary equation yields

$$\sigma_{JT} = \left(\frac{1}{1+r_f^T}\right)^2 ((1-\alpha-\tau)V(X_{SS},X_{DT},\mu_X,\sigma_X) - 2(1-\alpha-\tau)P_{ST}G(X_{SS},X_{DT},\mu_X,\sigma_X))$$

$$+\left(\frac{1}{1+r_f^T}\right)^2 \left(P_{JT}^2(\Phi(X_{DT},\mu_X,\sigma_X) - \Phi(X_{SS},\mu_X,\sigma_X)) + P_{JT}(1-\Phi(X_{DT},\mu_X,\sigma_X))\right) \quad (3.23)$$

c Equity

The payoff of the residual equity claim of a company with a tranched bond outstanding is given by equation 3.6. The expected discounted value of this claim is given by

$$\mu_{E_T} = \left(\frac{1}{1+r_f^T}\right)\mathbb{E}[\xi_{E_T}(X)] = \left(\frac{1}{1+r_f^T}\right)(1-\tau)\int_{X_{DT}}^{\infty} x\phi(x;\mu_X,\sigma_X)\,dx$$

$$+\left(\frac{1}{1+r_f^T}\right)((\tau-1)(P_{ST}+P_{JT}) - \tau(q_{ST}+q_{JT}))\int_{X_{DT}}^{\infty}\phi(x;\mu_X,\sigma_X)\,dx$$

Using equation 3.15, μ_{E_T} is expressed as

$$\mu_{E_T} = \left(\frac{1}{1+r_f^T}\right)(1-\tau)G(X_{DT},\infty,\mu_X,\sigma_X)$$

$$+\left(\frac{1}{1+r_f^T}\right)((\tau-1)(P_{ST}+P_{JT}) - \tau(q_{ST}+q_{JT}))(1-\Phi(X_{DT},\infty,\mu_X,\sigma_X)) \quad (3.24)$$

iii Annualized and discounted volatility of a bond's expected returns

The gross return of the corporate bond B, R_B, can be expressed as $R_B = \frac{\mu_B}{q_B^*}$, where μ_B denotes the security's $t = T$ expected value and q_B^* denotes the security's $t = 0$ equilibrium price. The *annualized and discounted volatility of a bond's expected return,* Σ_B, is then expressed as

$$\Sigma_B = \sqrt{\frac{\sigma_{R_B}^2}{T}} = \frac{1}{\sqrt{T}} \frac{\sqrt{\sigma_B^2}}{\sqrt{\left(q_B^*\right)^2}} = \frac{1}{\sqrt{T}} \frac{\sqrt{\mathbb{E}\left[\left(\xi_B\left(X^T\right)\right)^2\right] - \left(\mathbb{E}\left[\xi_B\left(X^T\right)\right]\right)^2}}{q_B^*} \tag{3.25}$$

where $\sigma_{R_B}^2$ denotes the discounted variance of a bond's expected return, ξ_B the bond's payoff[47] and σ_B^2 is the bond's variance.

[47]This could be either equation 3.1, 3.4 or 3.5.

II Standard parameters for the model in section 3.3

Standard parameters for the model in section 3.3				
Description	Parameter	Value	Source	Reason
Bankruptcy costs	α	0.23	Reilly et al. (2009)/Leland (2007)	Matches historical recovery rates in two period models.
Corporate tax rate	τ	0.2	Leland (2007)	Literature average[a].
Risk free rate per year	r_f	0.03	Federal Reserve Bank St. Louis[b]	10 year median 5-year treasury constant maturity rate.
Time to maturity	T	5 years	Bao and Pan (2010)	Med. corporate debt maturity.
Size of the company	X_0	100	Size of the company	The model scales linearly.
An. asset returns for all rating classes	r_X	0.12	Greer (2000)	Long term expected return on real assets proxied by commodities.
Annual asset volatility of a AAA company	ς_{AAA}	0.15		Chapter 2.
Annual asset volatility of a BBB rated company	ς_{BBB}	$0.23\frac{1}{2}$	Schaefer and Strebulaev (2008)	Estimate for a A company $+\epsilon$
Annual asset volatility of a B rated company	ς_B	0.27	Schaefer and Strebulaev (2008)	Inferred form table 7.
Detachment point HG/MG	$\Sigma_{HG/MG}$	$0.03\frac{3}{8}$	Reilly and Wright (1997) & Bao and Pan (2010)	Bond volatility and excess volatility estimates.
Detachment point MG/NIG	$\Sigma_{MG/NIG}$	0.045	Reilly and Wright (1997) & Bao and Pan (2010)	Bond volatility and excess volatility estimates.
Aggregated demand for HG risky bonds	Γ_{HG}	$\frac{1}{2} \cdot 10^{-3}$		Close to the standard trade off model.
Aggregated demand for MG risky bonds	Γ_{HG}	$\cdot 10^{-3}$	Schaefer and Strebulaev (2008)	Matches the leverage ratio of a BBB rated company.
Aggregated demand for NIG risky bonds	Γ_{HG}	$2 \cdot 10^{-3}$		High in order to model capital constrains.

[a] There is not much agreement on what the effective tax rate actually is. Some classical papers such as Leland (1994) use the statutory rate which is 0.35 (See 26 United States Code §11(b)(1) (2011)). More recent contributions on structural models such as Arnold et al. (2012) treat 0.15 as a standard. Nicodàme (2001) estimated the effective corporate tax rate at about 0.2 for the United States. The estimate of Markle and Shackelford (2012) lies in the same order of magnitude. This papers follows this estimate. This is inline with Leland (1998) as well as Leland (2007).

[b] http://research.stlouisfed.org/fred2/series/WGS5YR?cid=115, Accessed July 08, 2011.

Table 3.1: Values for parameters of the model in section 3.3.

Assumptions on corporate asset portfolios				
Description	Parameter	Value	Source	Reason
Annual asset volatility of low risk assets	ς_{LRA}	0.15	Chapter 2	Low in order to model high quality assets
Annual asset volatility of high risk assets	ς_{HRA}	0.28	Schaefer and Strebulaev (2008)	Asset volatility of NIG companies
Correlation between low and high risk assets	$\rho_{LRA/HRA}$	0.25	Leland (2007) e contrario	Average value

Table 3.2: Additional assumptions on the asset portfolio of a company that issues bankruptcy remote bonds.

III Illustrations

i Illustrations on capital structure trade offs

a Tranched bond

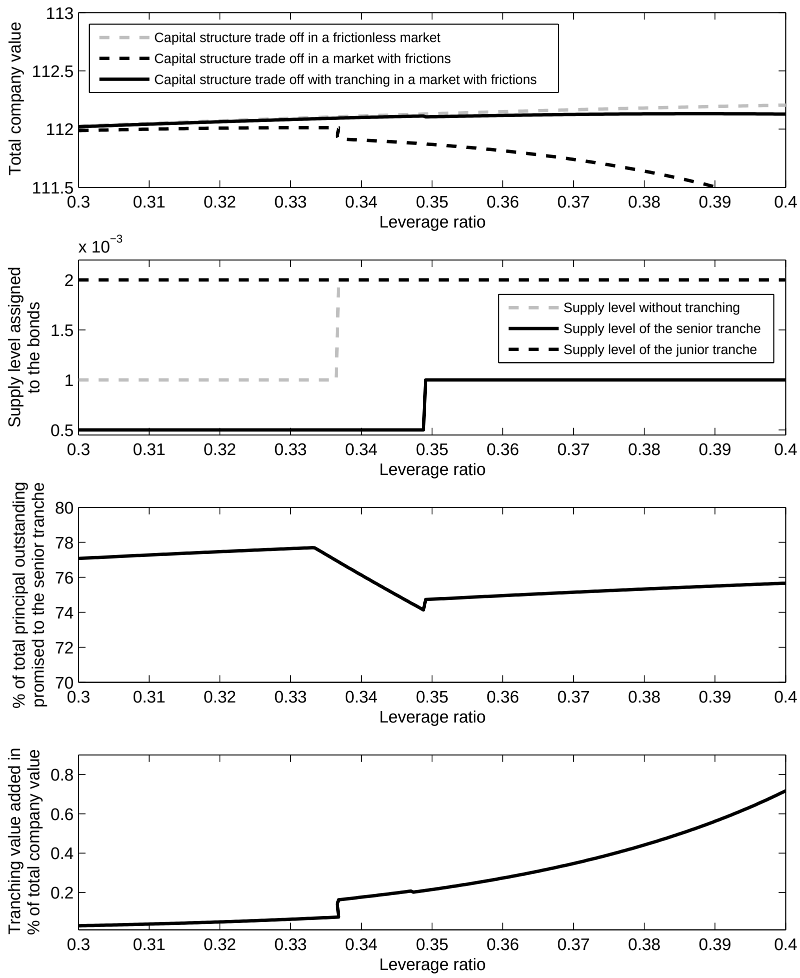

Figure 3.1: The capital structure trade off of a company with the asset volatility of a BBB rated company that applies tranching. The first panel depicts the capital structure trade off versus two benchmarks, the second panel depicts the associated supply levels, the third panel depicts the fraction of total principal outstanding that the company that applies tranching promises to the senior tranche and the fourth panel depicts the value unlocked through the application of tranching.

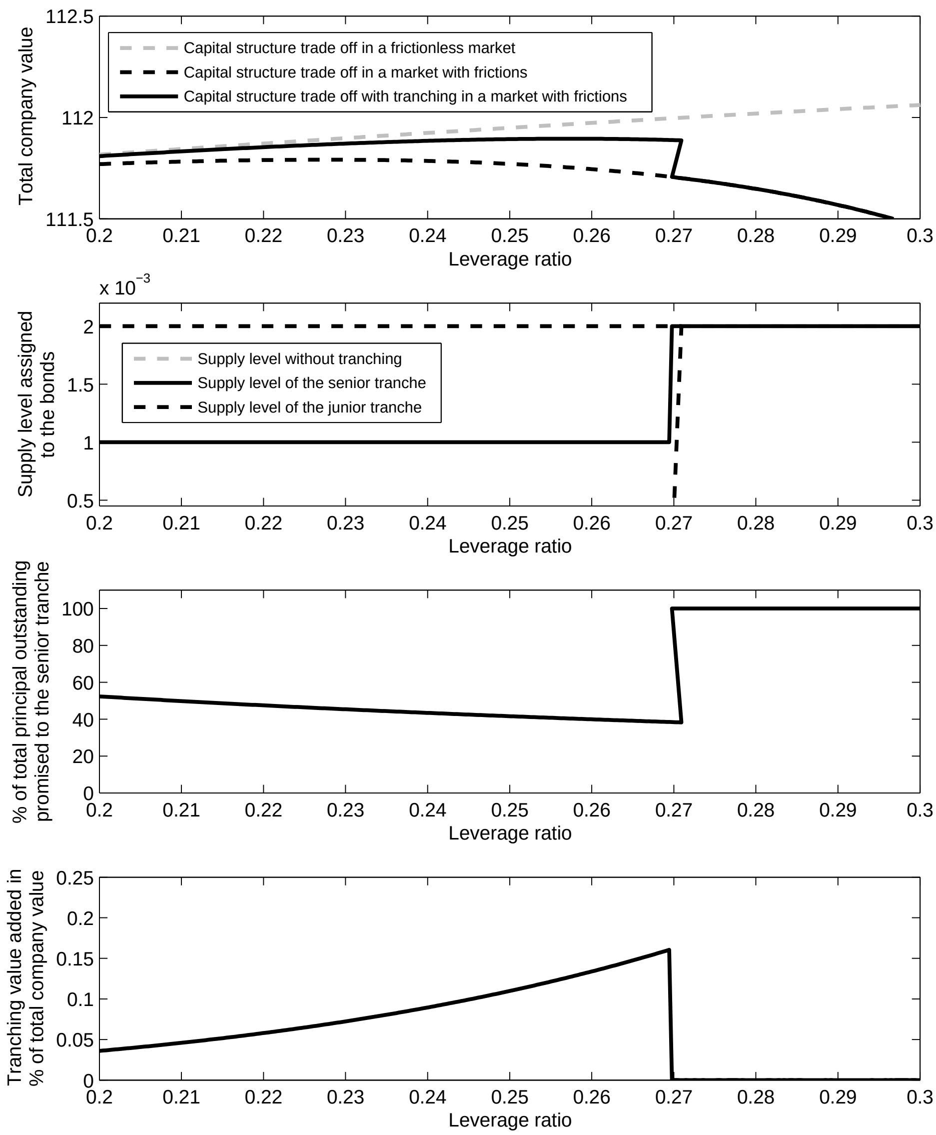

Figure 3.2: The capital structure trade off of a company with the asset volatility of a B rated company that applies tranching. The first panel depicts the capital structure trade off versus two benchmarks, the second panel depicts the associated supply levels, the third panel depicts the fraction of total principal outstanding that the company that applies tranching promises to the senior tranche and the fourth panel depicts the value unlocked through the application of tranching.

b Bankruptcy remote bond

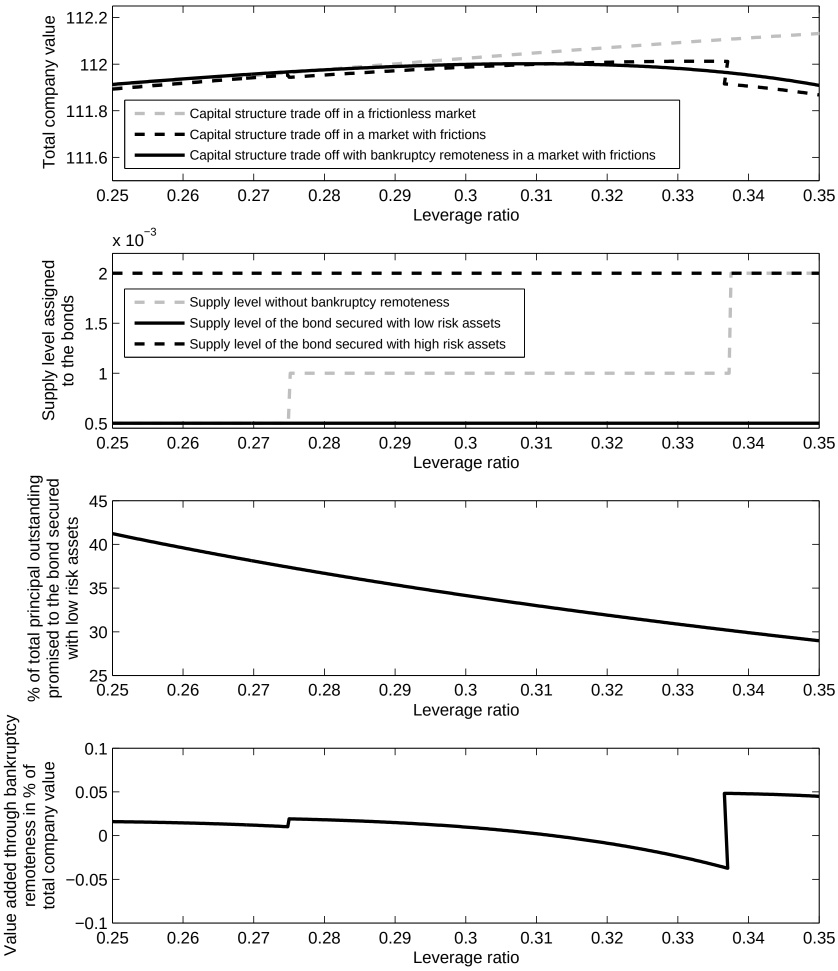

Figure 3.3: The capital structure trade off of a company with the asset volatility of a BBB rated company that applies bankruptcy remoteness. The first panel depicts the capital structure trade off versus two benchmarks, the second panel depicts the associated supply levels, the third panel depicts the fraction of total principal outstanding that the company that applies bankruptcy remoteness promises to the bond secured with low risk assets and the fourth panel depicts the value unlocked through the application of bankruptcy remoteness.

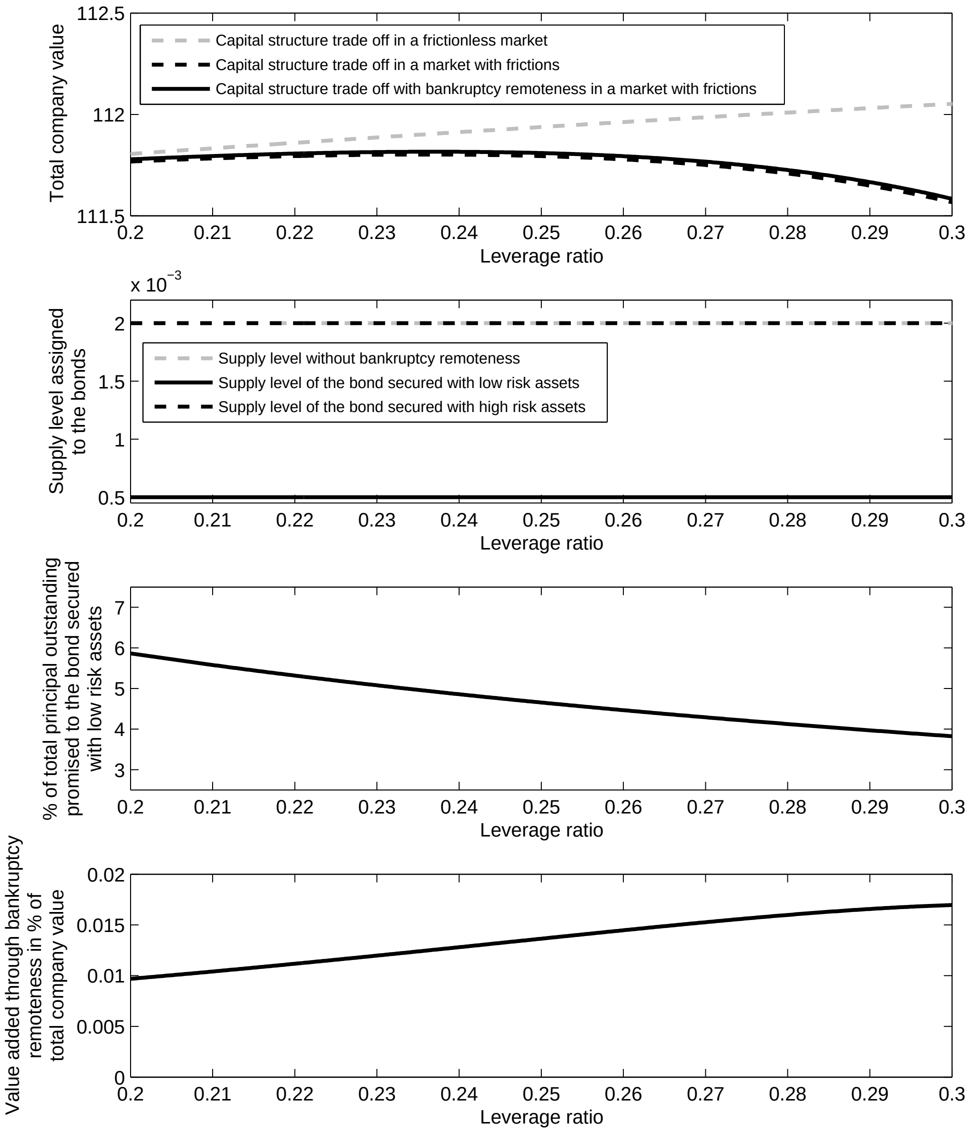

Figure 3.4: The capital structure trade off of a company with the asset volatility of a B rated company that applies bankruptcy remoteness. The first panel depicts the capital structure trade off versus two benchmarks, the second panel depicts the associated supply levels, the third panel depicts the fraction of total principal outstanding that the company that applies bankruptcy remoteness promises to the bond secured with low risk assets and the fourth panel depicts the value unlocked through the application of bankruptcy remoteness.

ii Illustrations on optimal capital structure

a Tranched bond

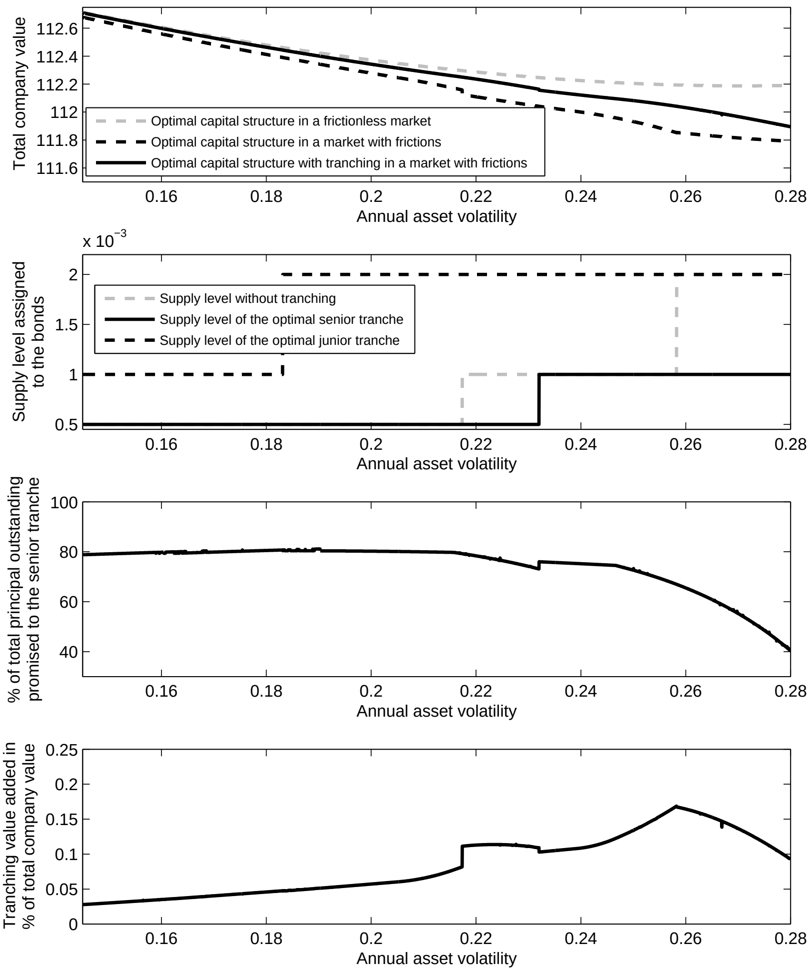

Figure 3.5: Optimal capital structure with a tranched bond. The first panel depicts the path of total company value with optimal tranching versus two benchmarks, the second panel depicts the associated supply levels, the third panel depicts the fraction of total principal outstanding that the company that applies tranching promises to the senior tranche and the fourth panel depicts the value unlocked through the application of optimal tranching.

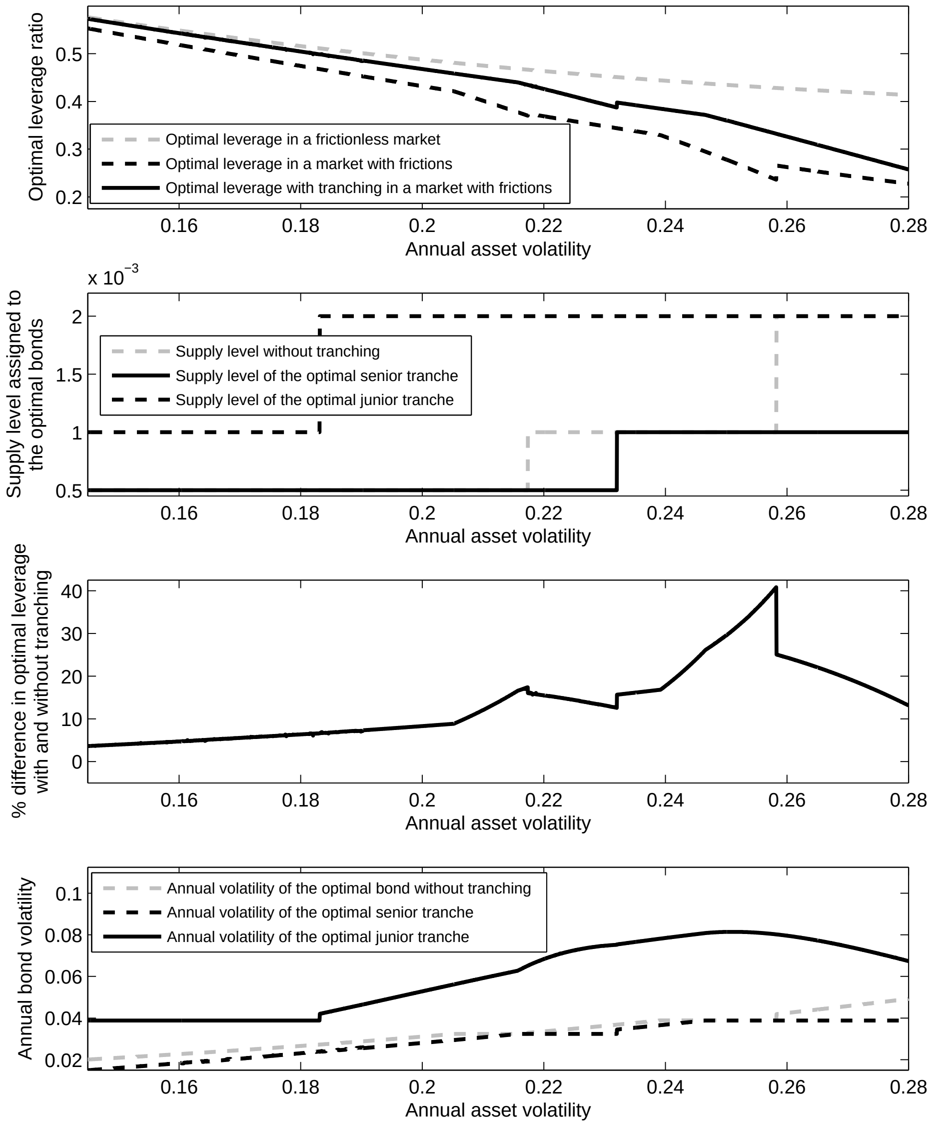

Figure 3.6: Optimal leverage with a tranched bond. The first panel depicts the equilibrium path of optimal leverage with tranching versus two benchmarks, the second panel depicts the associated supply levels, the third panel depicts the difference in optimal leverage between a company that applies tranching and a company that does not apply tranching, while the fourth panel depicts the annual volatilities of the optimal senior tranche, the optimal junior tranche and the optimal bond of a company that does not apply tranching.

b Bankruptcy remote bond

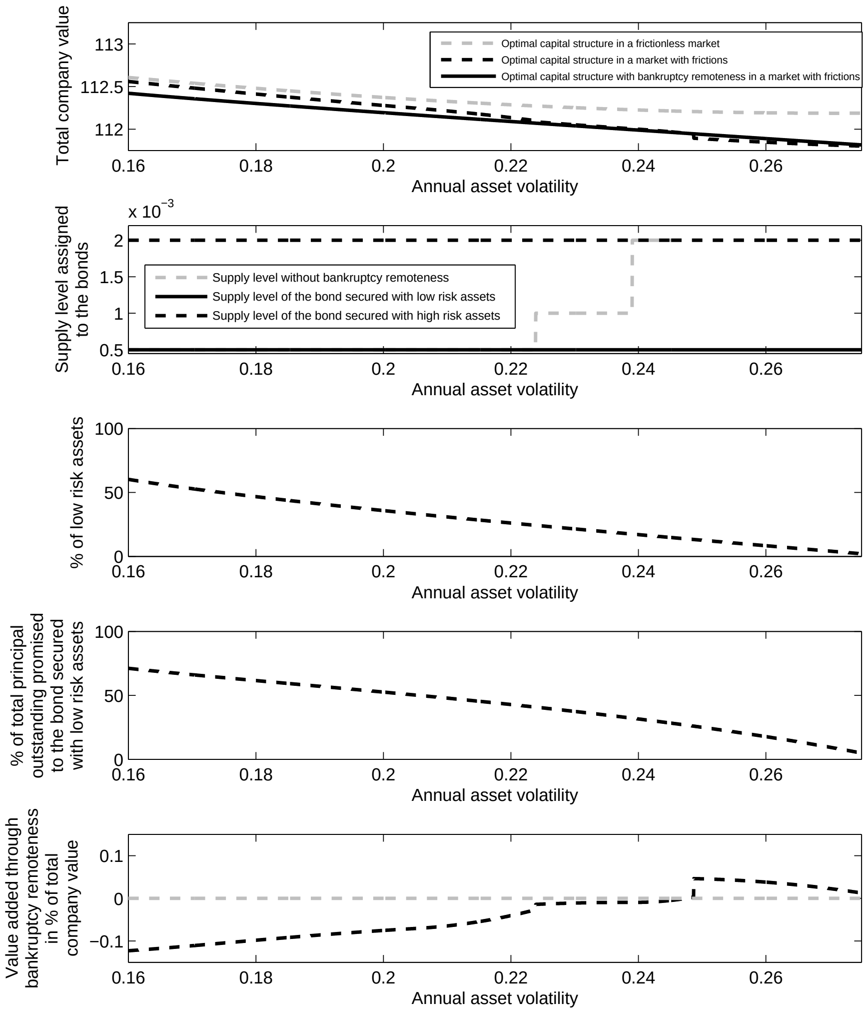

Figure 3.7: Optimal capital structure with bankruptcy remote bonds. The first panel depicts the path of total company value with bankruptcy remoteness versus two benchmarks, the second panel depicts the associated supply levels, the third panel depicts the fraction of low risk assets in the company's asset portfolio, the fourth panel depicts the fraction of total principal outstanding that the company that applies bankruptcy remoteness promises to the bond secured with low risk assets and the fifth panel depicts the value unlocked through the application of bankruptcy remoteness.

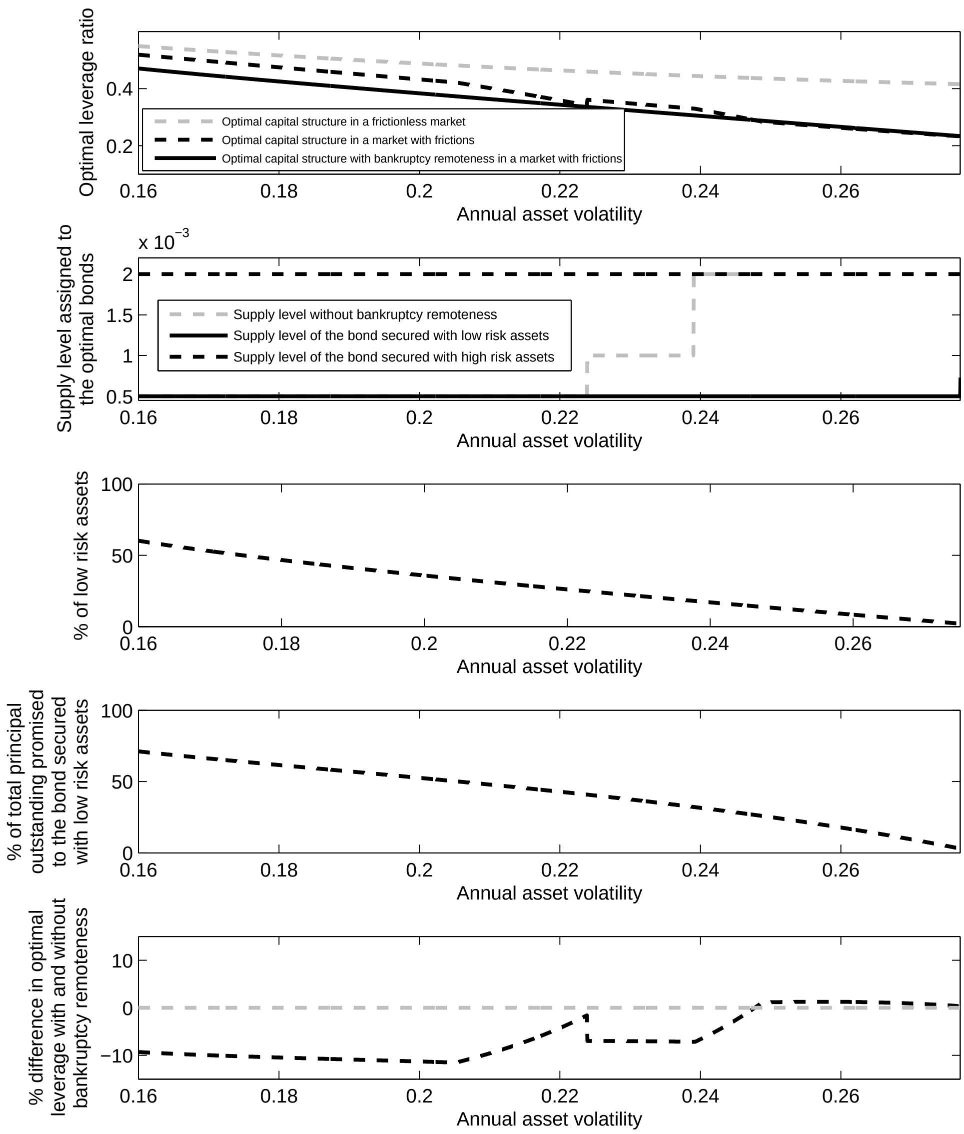

Figure 3.8: Optimal leverage with bankruptcy remote bonds. The first panel depicts the equilibrium path of optimal leverage with bankruptcy remoteness versus two benchmarks, the second panel depicts the associated supply levels, the third panel depicts the fraction of low risk assets in the company's asset portfolio, the fourth panel depicts the fraction of total principal outstanding that the company that applies bankruptcy remoteness promises to the bond secured with low risk assets, while the fifth panel depicts the difference in optimal leverage between a company that applies bankruptcy remoteness and a company that does not apply bankruptcy remoteness.

Part III

Curriculum vitae

Gabriel H. Neukomm - Curriculum vitae

Personal information

Born **December 6, 1983 in Zurich**

Educational background

2008 - 2012 **University of Zurich, Switzerland**
Swiss Finance Institute PhD Program in Banking and Finance

2009 - 2012 **University of St. Gallen, Switzerland**
Master of Arts in Law

2006 **The London School of Economics and Political Science, United Kingdom**
Summer School in Financial Econometrics

2003 - 2008 **University of Zurich, Switzerland**
Licentiate in Economics

Professional experience

2009 - 2012 **University of Zurich, Zurich, Switzerland**
Research assistant at the Department of Banking and Finance

2008 **Crédit Agricole Cheuvreux, Zurich, Switzerland**
Internship in sell-side equity research

Scholarships

2009 - 2012 **Swiss National Science Foundation fellowship for doctoral students (ProDoc)**

2008 - 2009 **Grant provided by Swiss Finance Institute during the first year of doctoral studies**